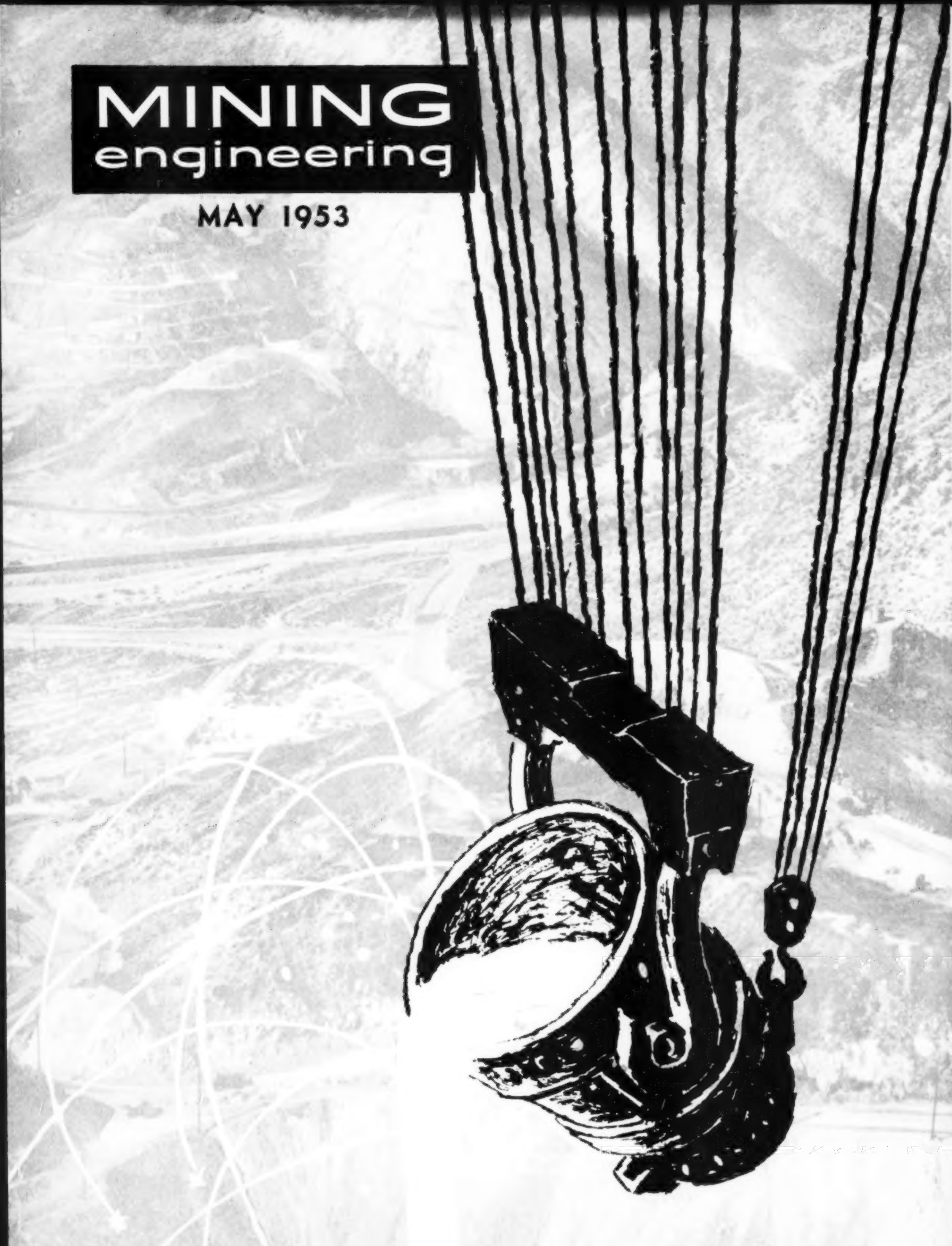
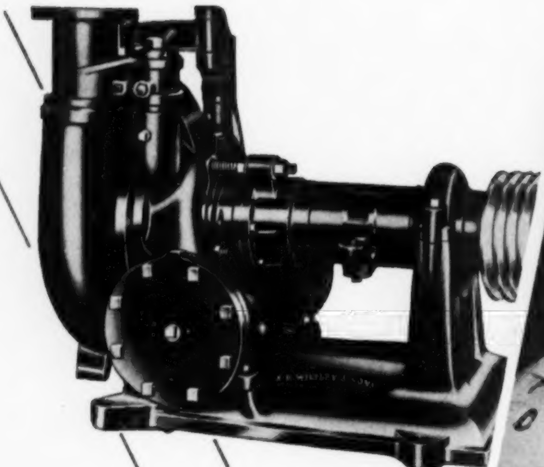
MINING engineering

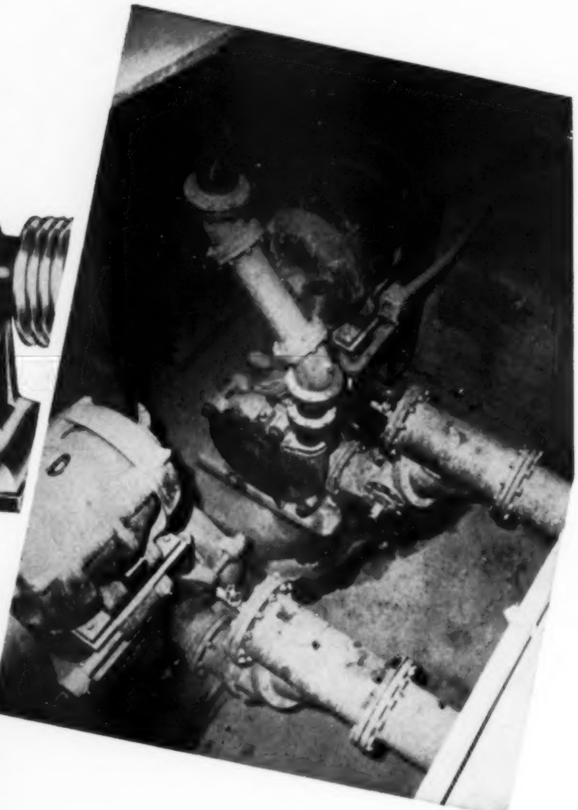
MAY 1953



HOW EAGLE MOUNTAIN HELPS KAISER MEET GROWING WESTERN STEEL NEEDS



Companion to the famous Wilfley Acid Pump



MINING engineering

VOL. 5 NO. 5 MAY, 1953

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COVER

This month's cover symbolizes the story starting on page 478, about operations at Kaiser's Eagle Mountain mine, and how the ore from there is handled at Fontana, the Pacific Coast's only integrated steel works.

FEATURES

ARTICLES

TRANSACTIONS

— Personnel Service —

THE following employment items are made available to AIME members on a nonprofit basis by the Engineering Societies Personnel Service, Inc., operating in cooperation with the Four Founder Societies. Local offices of the Personnel Service are at 8 W. 40th St., **New York 18;** 100 Farnsworth Ave., **Detroit;** 57 Post St., **San Francisco;** 84 E. Randolph St., **Chicago 1.** Applicants should address all mail to the proper key numbers in care of the New York office and include 6c in stamps for forwarding and returning application. The applicant agrees, if placed in a position by means of the Service, to pay the placement fee listed by the Service. AIME members may secure a weekly bulletin of positions available for $3.50 a quarter, $12 a year.

MEN AVAILABLE

Mining Engineer, Geologist, graduate M.I.T., 50, married, perfect health. Twenty years' experience operation, development, exploration and examination copper, iron, manganese, chrome, lead, zinc and magnesium properties in U. S. and Latin America. Fluent Spanish; go anywhere; employed. M-21.

Plant Engineer, 34, married, experienced mine plant layout and design, structures, construction and maintenance. Varied experience in mechanical field. Employed; available reasonable notice. M-22.

Metallurgist, 32, M.S. degree. Five years' experience in beneficiation of nonferrous and nonmetallic minerals. Desires responsible position in research or production. M-23.

Mine Shift Boss or Foreman, 34, single, graduate mining engineer. Five years' as miner and supervisor in Canadian base metal mines. Good knowledge heavy ground control. Employed, available 30 days notice. Desire permanent position. Location North or South America. Possibly also interested sales position with equipment company. M-24-533-E-5-San Francisco.

POSITIONS OPEN

Chief Engineer for large placer gold dredging operation in South America. Must be experienced in bucket line dredge operations, recovery methods, prospecting, property evaluation and general operational engineering. Salary open. Y8459.

Engineers. (b) Sales Engineers, with mining or construction background, to handle sales of mechanical underground and surface loaders. For the underground equipment, should have knowledge of underground mining conditions; and for the surface loaders, should be familiar with heavy construction work and open-pit mining. (d) Technical Sales Engineer for export department, to assist in technical sales, and who is familiar with overseas operation and able to handle French and German. Should have mining engineering background and be familiar with heavy underground and construction machinery. Salaries open. Y8342.

Mining Engineer, young, graduate, with some experience in surveying and mapping. Should be able to assume responsibility and get along well with associates. Duties will include mine and surface surveying and mapping, calculating and performing other related engineer work. Salary to start, $4200 a year with opportunities for advancement and salary increase. Location, South. Y8371.

Mining Engineer with experience in exploration and development for mining of hard rock. Must have experience in underground surveying. Give experience, age, and salary requirements. Location, eastern United States. Y8462.

Junior Engineers, recent graduates, single status, for large placer gold dredging operation in South America. (a) Mining Engineers. Salaries $3600 a year plus room and board plus annual bonus. Y8450.

Metallurgist, mining or metallurgical engineering graduate, with at least 5 years tin ore analysis and milling experience for semi-pilot plant operation. Salary open. Location, Africa. Y8380.

Junior Mining Engineer, recent graduate or one year's experience, for survey and flotation in ores and general engineering. Any special courses in ore dressing desirable. Salary, $4200 a year. Location, North Carolina. Y8544.

Geologist with experience on gold and silver, to estimate potentiality of such a property in Mexico. Prefer resident of Mexico. Headquarters, New York, N. Y. Y8551.

Meet The Authors


PAUL F. KERR


J. WALTER SNAVELY


E. W. FELEGY

Raymond Robinson (P. 495) spends most of his leisure hours outdoors. During winter months he takes to the ski trails and in the summer he climbs. Archeology and anthropology—excavation and American Indian artifact collecting—mineral and ore specimen collecting, big game hunting, canoeing and hiking are other important interests. Mr. Robinson graduated from Union College, Schenectady, and McGill University, Montreal, earning a Bachelor of Science in Geology and a Master of Science in Mining Geology, respectively. He also has done graduate work at Harvard toward a Ph.D.

Paul F. Kerr (P. 495) of the Department of Geology, Columbia University, is a graduate of Occidental College and Stanford University. He attained his Ph.D. from the latter school. Mr. Kerr has been with Columbia since 1924. He was a professor of Mineralogy from 1944 to 1950, research coordinator, technical consultant to the Army-Navy Munitions Board, technical consultant to the Manhattan District, and is a past president of the Mineral Society of America. Mr. Kerr has published about 80 papers in various publications. An AIME member, he likes to travel and take his camera with him, recording his itinerary in color.

J. Walter Snavely (P. 512) has spent most of his career to date in the materials handling field. A graduate of the University of Wisconsin, he has occupied several responsible engineering positions in application and research with the Chain Belt Co. Before returning to Milwaukee, his present home, Mr. Snavely resided in the Southwest for seven years.

E. W. Felegy (P. 518) is the author of various Bureau of Mines publications on applications of analyses of complex mixtures of gases, acid mine water studies, and underground radio communication. The titles cover his principal field of work for the Bureau of Mines. He has been a mining engineer with the Bureau since 1946, at Pittsburgh, Salt Lake City, and Duluth. Mr. Felegy earned his Bachelor of Science in Mining Engineering at Lehigh University, and Master of Science in Mining at the University of Minnesota. He prefers golf, bowling and bridge for fun, although sometimes, according to Mr. Felegy it's difficult to tell the bowling scores from the golf scores.

Letters to The Editor

Committee on Milling Methods

Dear Sirs:

I am very glad to send you this letter over the Pacific Ocean. I am one of the people who respect you and the Institute heartily in this country. I graduated from Seoul Mine College which was in our capital in 1941, and then have studied mineral dressing in the only one research institute attached to the Bureau of Mines. Now I have been displaced to Chonju over a hundred miles south from Seoul because of the war, and I am in the charge of the lecture of ore dressing at the Technical Col., Chunbuk Univ.

You see, our country has been cut into two, and they have engaged in battle with each other over two years. Though it is a part of the war between democracy and communism of the world scale, it is too much miserable and merciless for us of a lesser power to overcome. We Koreans are all thankful for your mental, physical and especially military assistances.

I think you have found Korea on your map recently only through the war. Indeed our country is very small and weak, and not worth being concerned with. But we mine engineers and metallurgists don't accept such an opinion. We have produced thousands of tons of wolframite and scheelite concentrate for the past seven years and have sent it all to your smelter, and recently you know, the Tungsten Agreement was made between U. S. and Korea Governments.

I was engaged in the study of the milling method of scheelite ore produced at Sangdong Mine which was the greatest tungsten mine in Korea. But it was a very hard work. Because of the overgrinding the recovery was below 60%. We must try to raise up, but we have no means of study, technic, testing apparatuses and references.

I have some references on ore dressing among which works of Mr. Taggert, Gandin, Wark, Richards, Locke, Gunther, Truscott, Hoover, Chapman-Mott, Wiard, Simons and so on were there, and Transactions and Milling Methods of A.I.M.E. and magazines were too. But they were burnt out in furnaces, sold at markets as waste paper by ignorant people after we left Seoul escaping from the communists.

Recently I have found the address of A.I.M.E. written in "Milling Methods" 1935, and I am now writing to offer your kindest favor for me. My hopes are as follows:

A. I hope to exchange letters with anyone of you who feels interested in teaching and developing the technics of ore dressing in Korea.

B. You will please let me know the recent trends of the technics on ore dressing in U. S., for I have not heard of it since the beginning of the War II.

C. Please introduce me good references on ore dressing.

D. Kindly let me know the means to get the following books at low costs or by any other desirable means.

I wish you will excuse me for the rudeness. I shall remain as one of your followers waiting for your answer.

Yours faithfully,
Kang Moon Lee
Shinheung High School
Chonju, Cholla-puk-do

P.S.—The books I need are as follows: Taggart: Handbook of Mineral Dressing; Wark: Principles of Flotation; Chapman-Mott: The Cleaning of Coal; A.I.M.E.: Milling Methods, 1939, etc.; Wiard, Simons, Rabone.

This appears to be a worthwhile opportunity for practical efforts at better foreign relations. The Mining Branch Secretary will be glad to forward any material offered.

Books for Engineers

ORDER YOUR BOOKS THROUGH AIME—Address Irene K. Sharp, Book Department. Ten per cent discount given whenever possible. Order Government publications direct from the agency concerned.

Minerals—A Key to Soviet Power, by Demitri B. Shimkin. *Harvard University Press.* $8.00, 452 pp., 1953. —The book is an economic evaluation of the position of the Soviet Union in respect to mineral wealth and development. Various sources are drawn upon, including the reports issued after completion of the various five year plans. The book is of considerable reference value despite the confusion which beclouds information concerning Soviet mineral progress. The theoretical study is the joint product of some of the staff of the Harvard University Russian Research Center. The author's approach to metals and nonmetals in the Soviet Union is systematic and he presents a great deal of data covering the period 1926 to 1950. Indicated weaknesses in the mineral economy are highlighted. Some considerable space is given to Soviet mineral future.

Saudi Arabia, second edition, by K. S. Twitchell. *Princeton University Press.* $5.00, 231 pp., 1953.—The stated purpose of the book is to give the western world some idea of Saudi Arabia and its ruler King Abdul Aziz ibn-Saud. The second edition of the book brings the reader closer to changes which have taken place in that country between 1946 and 1952. An account of development of natural resources is presented, with chapters devoted to mining and petroleum advances. Geographical and geological data chapters are included in the first section. The book is illustrated with maps and photographs.

Applied Inorganic Analysis, second edition, by W. F. Hillebrand and G. E. F. Lundell, revised by G. E. F. Lundell, H. A. Bright, J. I. Hoffman. *John Wiley & Sons, Inc.* $15.00, 1034 pp., 1952.—Aim of this second edition is to describe methods of separation and determination that have proved of value, or that promise to have value, in applied inorganic analysis, rather than to list or describe methods of limited application. New material has been added and some old has been discarded. Many of the chapters have been revised and some rewritten. Rewritten chapters are those on columbium, tantalum, tin, and the platinum metals. The chapter on uranium has been expanded in proportion to the wealth of new material on hand since the first edition. Brief discussions on the new topics, polarography, chromatography, flame photometry, fluorometry, mass spectrometry, X-ray analysis, are presented. Fundamentally unchanged are the chapters dealing with silicate and carbonate rock analysis. The book is intended to be supplementary to *Outlines of Methods of Chemical Analysis,* by Lundell and Hoffman.

Recent U. S. Patents

2,627,399 Pelletizing for cement clinker manufacture. (2/3/53) *Erie Mining Co.*

2,627,452 Preparation of lithium chloride from spodumene. (2/3/53) *Scientific Design Co.*

2,627,654 Mining drill bit extractor. (2/10/53) *Clifford J. King,* Malartic, Que.

2,627,930 System for underwater seismic exploration. (2/10/53) *Atlantic Refining Co.*

2,627,976 Belt type magnetic separator. (2/10/53) *Roswell H. Stearns.*

2,627,978 Floating support for thickener mechanism. (2/10/53) *Paul A. Curtis.*

2,628,037 Hammermill type crusher. (2/10/53) *George E. Krider.*

2,628,154 Recovery of chromates and vanadates from solution. (2/10/53) *Diamond Alkali Co.*

2,628,716 Sulphide flotation process with thiopyrimidine reagent. (2/17/53) *Koppers Co.*

Purchase U. S. Patents ($0.25 ea.) from:
Commissioner of Patents
Washington 25, D.C.

U. S. Bureau of Mines Publications

RI 4928 Pegmatite investigation in South Dakota. 46 pp.

RI 4931 Formation of dithionate and sulphate in manganese ore leaching. 13 pp.

RI 4933 Theoretical precision of screen analysis results. 9 pp.

RI 4737 Iron sulphide deposits, Aitkin and Carlton Cty., Minn. 33 pp.

RI 4939 New Anniversary-Bucky pegmatite, Gunnison Cty., Colo.

Request free publications from:
Publications Distribution Section
U. S. Bureau of Mines
4800 Forbes St.
Pittsburgh 13, Pa.

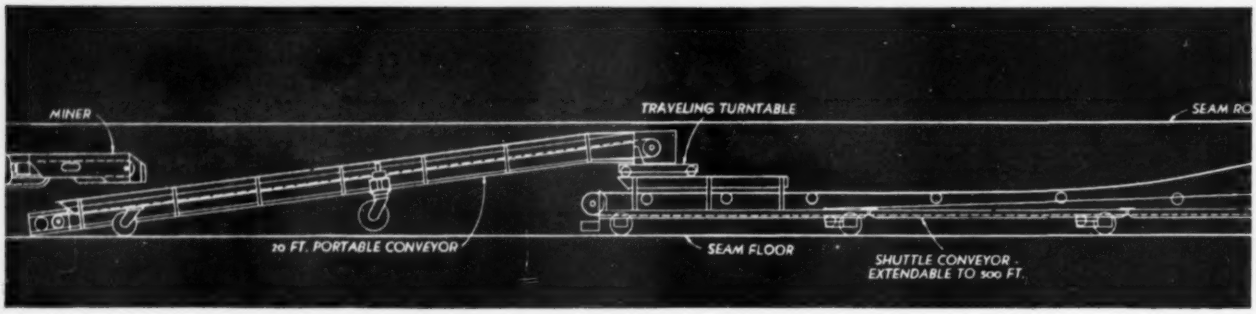
U. S. Geological Survey Publications

PP 248A Mica deposits of Southeastern Piedmont, Pt. 1. $1.25.

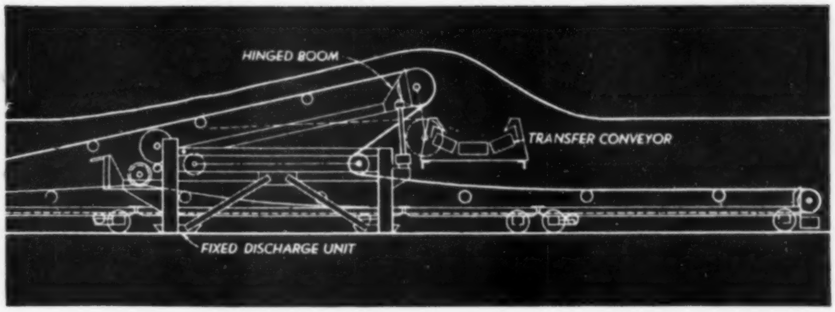
Bull 988-C Uranium in Lyon Cty. Nev. $0.35.

Bull 988-D Distribution of uranium in rich phosphate beds of Phosphoria formation. $0.15.

Purchase U. S. G. S. Papers and Bulletins from:
Government Printing Office
Washington 25, D. C.



Here's the New Answer to



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It's The Hewitt-Robins Mine Type Shuttle Conveyor With Fixed Tripper

The Hewitt-Robins Mine Type Shuttle Conveyor with fixed tripper forms the final link in a complete belt conveyor system that can handle an uninterrupted flow of ore directly from the face to the surface as fast as any mechanism can produce it.

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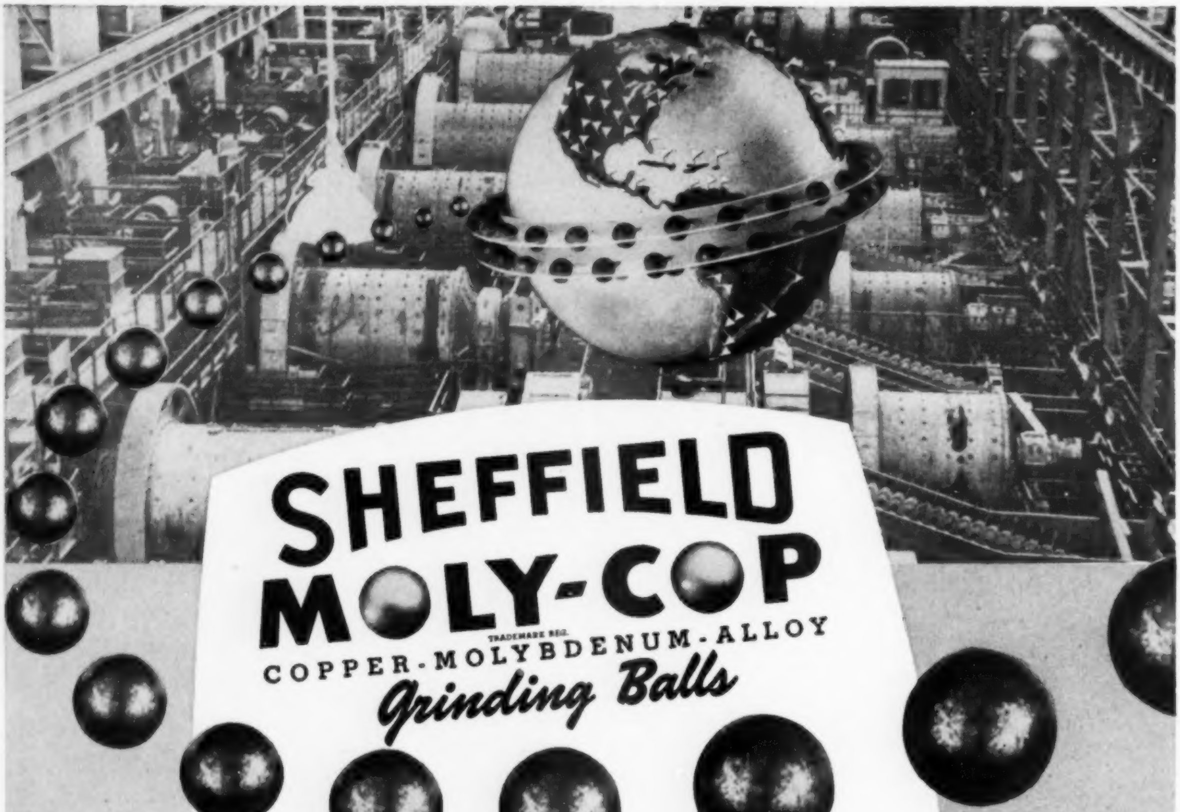


Manufacturers News

DynArc

New process for cutting and piercing stone, concrete, and refractory materials uses a unique arc. Process, announced by ChemoTec Div. of *Eutectic Welding Alloys Corp.*, features

Flue Pipe Granite

first use of an arc rod upon non-conductive materials. Key to method is Dynatrode, which creates its own arc, requires no ground and does not have to be struck on metal. The arc operates in mid-air, producing a 5 to

8-in. flame with temperature of 8000°. Only operating requirement is a dc welding machine of 400-amp capacity. Cutting masonry, preparing mounting holes in concrete are among its applications. **Circle No. 1**

Conveyor Belt

First rubber transmission belt ever made with all rayon fabric is said to be 25 pct stronger and have up to 10 times greater flex life than cotton fabric belts made with same number of plies. Stretch of all rayon belt is also said to be reduced. The new belt is result of five years of tests and field development by *B. F. Goodrich Co.* **Circle No. 2**

Neutralizer

Water Neutralizing Co. has developed a process for neutralizing acid waters. Savings are claimed in prolonged use of pumps, pipelines, screen cloth, conveyor parts, and where dryers are used. **Circle No. 3**

Winch

A mechanical hand-winch with capacity to 10,000 lb, designed for optional use with an electric drill, is available from *Stampco Products Co.* Readily portable, the Handiwinch is suitable for industrial and construction uses. Brake design allows safe load spotting. **Circle No. 4**

Power Package

The *P&H* Diesel Power-Package is called a new idea in power application for shovels, planned to give the economy and operating advantages of a diesel in shovels now gasoline powered. The unit is a complete replacement package to dieselize the shovel. Claimed to cut operating costs, down time and maintenance troubles the unit features the *P&H* 3-cylinder, 2-cycle engine designed for shovel service. **Circle No. 5**

Pumps

Thrustfre centrifugal pumps, built by *Pennsylvania Pump and Compressor Co.* in sizes up to 5-in. and capacities to 1300 gpm at 1200 psig, have first stage impeller of double suction type to handle lower net positive head, and stuffing boxes at both ends are subjected to low pressures. **Circle No. 6**

Liquid Level Control

Based on capacitive action of liquid surrounding a porcelain covered electrode, the Belmont level control made by *Thermo Instruments Co.* has applications for liquid level and blending control in all types of chemical operations. **Circle No. 7**

Car Loader

A centrifugal thrower designed to load box cars with granular material and small lump to 2-in. size at a rate

of 80-tons per hour is available from *Stephens-Adamson Mfg. Co.* The operator can load and trim the car without entering, by using the thrower pivot. **Circle No. 8**

Shoveloader

Designed to speed bulk materials handling the *Baker-Lull* Shoveloader is available with eight accessory attachments. Claimed to have more forward reach and higher lift than similar equipment, the loader is equipped with double acting hydraulic cylinders for precision load control. **Circle No. 9**

Belt Fasteners

Flexo belt fasteners for conveyor and elevator belts are now available from *Flexible Steel Lacing Co.* with assembled bottom plates to save time. **Circle No. 10**

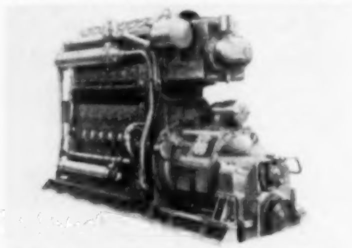
Automatic Sampler

New design of the *Denver* automatic sampler gives simplicity and eliminates complicated wiring circuits. A time switch may be set for intervals from 2 to 55 min, varying

by one-minute intervals. Cutter assembly has positive drive by roller chain, and a magnetic brake prevents overtravel. Standard cutter travel is 21 in., and longer sweep is available. **Circle No. 11**

Diesel

A new opposed-piston diesel for heavy duty applications in the 225 to 750 hp range has been announced by *Fairbanks, Morse & Co.* Compact



and light, it was designed for power plant, marine, and railroad use. Continuous duty rating is 75 hp per cylinder, and the 225 hp unit weighs 7100 lb. **Circle No. 12**

Laboratory

Ledoux & Co., chemists and assayers, have announced completion and

operation of their new 21,000 sq ft laboratory and office in Teaneck, N. J. **Circle No. 13**

Sheave Block

Pacific Round-the-Corner sheave block made by *Alloy Steel & Metals Co.* is an entirely new product to cut cost in underground mucking by eliminating double slushing. One example given claims 50 pct cut in cost of mucking out square-set rounds. Use of the Pacific sheave enables scrapers to turn a corner, unaided and without uncoupling. **Circle No. 14**

Free Literature

(15) DIAMOND DRILL: Details of the CP-55 diamond drill are given in a bulletin from *Chicago Pneumatic Tool Corp.* Said to be faster than any other drill in its class the CP-55 is light-weight, easy to handle, and powerful enough for either blast hole or exploratory drilling.

(16) JAW CRUSHERS: A *Denver Equipment Co.* bulletin covers construction and operation of two types of Denver jaw crushers. Both have steel frames, type H has anti-friction bumper bearings and bronze side bearings, type J has anti-friction bumper and side bearings.

(17) LUBRICATION: Lubriplate Div. of *Fiske Bros. Refining Co.* has available a 56-page Data Book. Called a treatise on lubrication, it is aimed to improve operation of machinery and reduce maintenance costs.

(18) MOTORS and GENERATORS: *Allis-Chalmers Mfg. Co.* has made available a 50-page reference booklet to assist in selection of motive power to handle most industrial applications. The pamphlet is reprinted from the 1952 edition of Lincoln's Industrial-Commercial Electrical Reference. Basic types of motors and generators, standard ratings and sizes, and application specifications are fully covered.

(19) CAR SPOTTERS & PULLERS: New book on electric car spotters and drum-type car pullers, issued by *Link-Belt Co.*, describes a complete line of equipment for moving railroad cars and other heavy loads.

(20) IDEAS: A mechanism for "Putting Ideas to Work" is outlined in a booklet by *Battelle Development Corp.* It describes a means of utilizing patents and ideas that corporations might otherwise let lie idle because they fell outside their manufacturing interest, or because further work was required to carry them to a practical use.

(21) AIR PURIFICATION: Product and process control, and health protection are the primary fields of use for the *Mine Safety Appliances Co.'s* Ultra-Aire Space Filter. Efficiency of filter is guaranteed to 99.95 pct against particles of 0.3 micron size, and the filter has proved effective in handling particles to 0.05 micron. Details of the Silene-treated asbestos filter fibers, and data on applications are contained in a new bulletin.

(22) HOISTS: A complete new catalog issued by *Sauerman Bros. Inc.* contains full information on Sauerman hoists for operating power scraper excavators and storage machines, for use on slackline cableway excavators and tautline cableways. Photographs and detailed descriptions are provided of each specialized type of hoist.

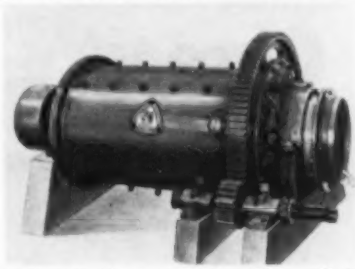
(23) PLASTIC PIPE: Bulletin from *Yardley Plastics Co.* presents characteristics of their flexible plastic mine pipe. Sizes from ½ to 6 in. are available together with a complete range of insert fittings. Pipe is suitable for handling working pressures of 150 to 300 psi depending on size.

(24) PUMPS: Construction features of *Allis-Chalmers* small vertical pumps for sidewall or submerged mounting are described in new bulletin. Units are available in capacities to 250 gpm and heads to 125 ft for coolant circulation, air conditioning, etc.

(25) DRAWPOINT LOADING: Topic of an *Eimco Corp.* bulletin is drawpoint loading for saving time and money, speeding production and increasing safety.

(26) GRIZZLY: Full details of the Symons Rod Grizzly for heavy duty service handling large tonnages of sticky, wet or gummy ores and rock have been prepared by *Nordberg Mfg. Co.* in a recent bulletin.

(27) BALL-ROD MILL: *Denver Equipment Co.'s* 30-in. diam Convertible Mill has been improved for greater convenience in modification



and to facilitate repairs. The mill is available in 30x18 to 30x72-in. sizes. Type of discharge opening, small, medium, or large trunnion overflow, can be changed by installing correct throat liner, and grate liners may also be used.

(28) CONCRETE: Theory and practice of obtaining good concrete is the subject of "Plastiment Concrete Densifier" published by *Sika Chemical Corp.* Controlling cement hydration to reduce cracking and improve hardness and impermeability is principal topic.

(29) ABRASIVES: Adaptability, versatility and application of *Cratex Mfg. Co.* rubberized abrasives, together with complete specifications on the product in wheel, point, stick, block, and cone form is provided in a new catalog.

Mining Engineering — **May**
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Additional Applications of Cyanogen Compounds in Base-Metal Flotation

AERO DEPRESSANT #675
A New 600 Series Reagent

This noteworthy addition to the 600 Series of Cyanamid Reagents and Processes is a highly selective depressant for metallic sulphides. It provides better control and more accurate separation than reagents heretofore available for many lead-zinc, copper-lead, copper-zinc, etc., ores. It can be used both in bulk float or for selective separations. Where precious metals are present, it has the added advantage of not dissolving gold or silver. While not a low-priced reagent, the unusually sharp selectivity of AERO* DEPRESSANT #675 warrants its test on any hard-to-treat sulphide, as these typical results indicate:

Normal flotation methods on a Philippine lead-copper-zinc ore produced a lead-copper concentrate containing galena, chalcopyrite, sphalerite, and pyrite. Treatment of this concentrate with AERO DEPRESSANT #675 gave these results:

	ASSAYS %		RECOVERY	
	Pb	Cu	Pb	Cu
Lead-Copper Conc.	46.9	8.9	100.0	100.0
Lead Concentrate	76.6	1.5	92.3	9.8
Copper Concentrate	8.4	18.41	7.3	90.2

On an African lead-copper-zinc ore in which the copper minerals are enargite, tennantite, bornite and chalcocite, the usual lead-copper concentrate was treated with AERO DEPRESSANT #675. Subsequently, the resulting lead concentrate was cleaned with additional AERO DEPRESSANT #675 to produce a cleaned lead concentrate, a lead tailing and a copper concentrate as follows:

	ASSAYS %		RECOVERY	
	Pb	Cu	Pb	Cu
Lead-Copper Conc.	53.8	15.3	100.0	100.0
Lead Concentrate	75.8	1.7	94.0	7.4
Lead Cleaner Tail	35.0	18.4	2.4	4.5
Copper Concentrate	6.5	45.5	3.6	88.1

AMERICAN *Cyanamid* COMPANY

* Trade Mark

AERO CYANIDE to Increase Zinc Recovery from Tarnished or Slimy Ores

Recent comparative tests in the Cyanamid Mineral Dressing Laboratory indicate that the addition of a small amount of AERO® Brand Cyanide can substantially increase recovery and improve grade on tarnished zinc sulphide ores and tailings and on slimy zinc ores.

In this typical series of tests on jig tailings and dump ores, Cyanamid metallurgists added a half-pound of Aero Brand Cyanide per ton of feed to the mill; conditioned with Copper Sulfate and SODIUM AEROFLOAT® Promoter and frothed with Pine Oil. Control tests on these samples were identical, except for the omission of cyanide. These spectacular improvements in recovery and grade were obtained:

ASSAYS % ZINC WITH AERO CYANIDE

	Calc. Heads	Conc.	Tails	Zinc Recov.
Jig Tailing #2	4.54	59.86	0.10	96.3
Jig Tailing #3	3.86	59.59	0.06	97.4
Jig Feed #4	13.86	64.82	0.29	96.4
Tailing Dump #5	5.07	62.62	0.02	97.6
Tailing Dump #6	3.93	58.35	0.07	96.5

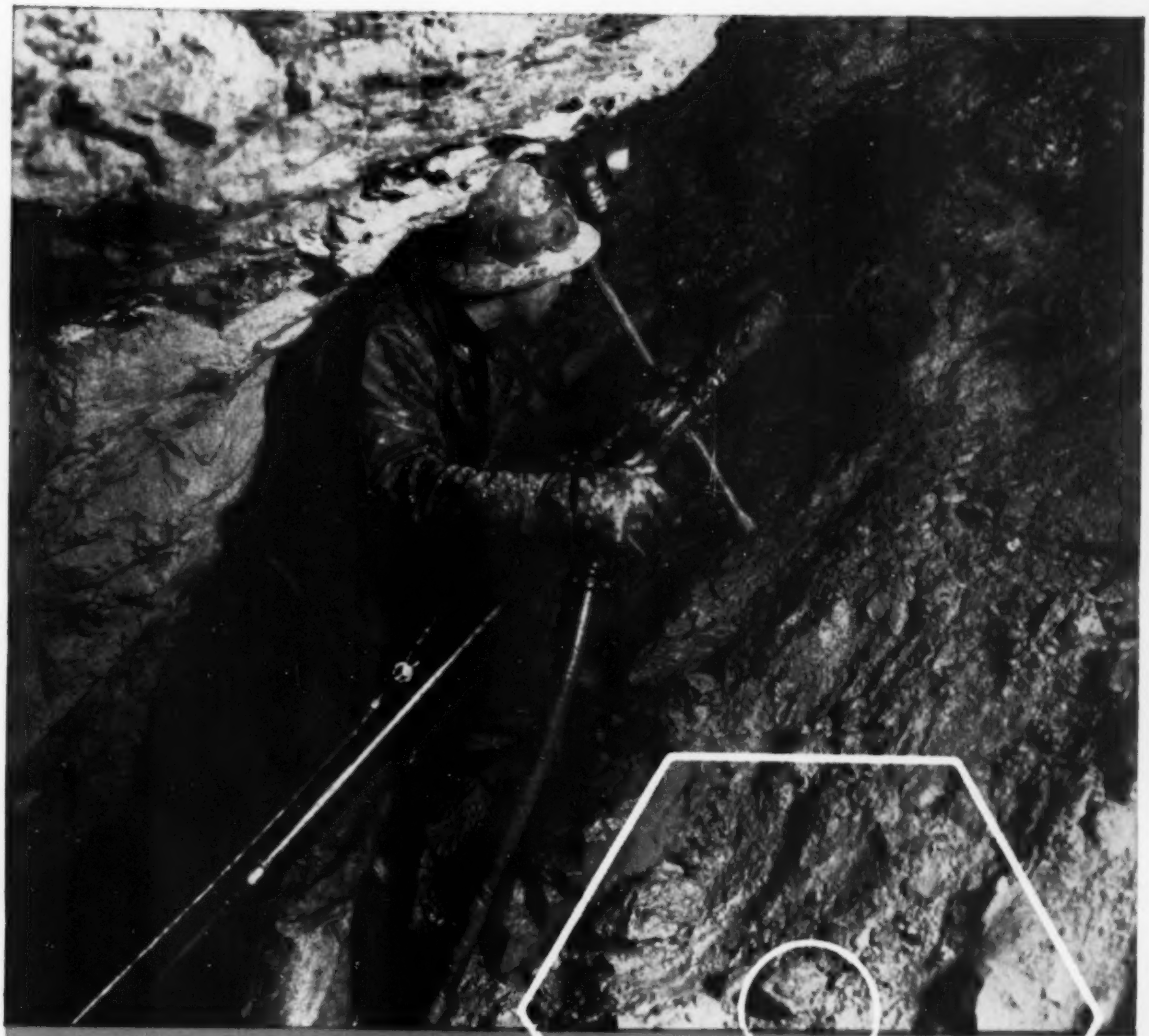
ASSAYS % ZINC WITHOUT AERO CYANIDE

	Calc. Heads	Conc.	Tails	Zinc Recov.
Jig Tailing #2	3.44	47.08	0.20	93.1
Jig Tailing #3	3.73	62.50	0.32	90.6
Jig Feed #4	12.65	62.22	0.54	94.4
Tailing Dump #5	5.29	61.80	0.77	85.2
Tailing Dump #6	3.07	59.85	0.73	76.0

Important supplier of Cyanide for over thirty years, Cyanamid has continuously explored the development of Cyanogen Compounds and Processes for their application to mineral beneficiation. Through a world-wide interchange of information flowing to and from the Cyanamid Mineral Dressings Laboratory, Cyanamid Field Engineers are kept continuously informed of all advances in milling methods, reagent combinations, processes and application techniques. Supplemented by the original research and testing in Cyanamid Mineral Dressing Laboratory, this constitutes a [illegible] reservoir of ore-dressing data available to mill men everywhere as part of Cyanamid's Complete Metallurgical Chemical Service.

CN

MINERAL DRESSING DIVISION
30 ROCKEFELLER PLAZA, NEW YORK 20, NEW YORK



No Maintenance in 11 years

Mine cars show economy of high strength low alloy steel containing Nickel

Look at these cars after 8 years in deep mine service, then operated for three years in strip mining . . .

Glance at the interior to verify the remarkable 11-year performance of ¼" U·S·S Cor-Ten . . . a high strength low alloy steel containing nickel produced by UNITED STATES STEEL CORPORATION. Despite hard usage, acidulous mine water and other corrosive operating conditions, none of the steel parts of these cars has required maintenance — not even painting.

Why? Because steels like this are stronger and tougher than plain carbon steel…and definitely more resistant to impact, abrasion, wear and corrosion.

Produced under various trade names by leading steel companies, these high strength steels containing nickel along with other alloying elements, provide three basic advantages:

1. Good resistance to corrosion, abrasion and impact.
2. High strength in the as-rolled condition, permitting important weight reductions or improved factors of safety.
3. Excellent response to usual fabrication operations, including easy forming and welding.

At the present time, nickel is available for end uses in defense and defense supporting industries. The remainder of the supply is available for some civilian applications and governmental stockpiling.

EMBLEM OF INCO SERVICE

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y.

Mining and oil industry representatives are scheduled to testify May 15 at hearings on the Simpson bill to extend the Reciprocal Trade Agreements Act. Several Congressmen have introduced bills to extend present trade agreements without modification.

Price of copper appears to be stabilizing at 30¢ per lb, after a period where market price ranged from 27 to 34¢. Copper offerings from abroad were finding no takers at 30.24¢ per lb late in April.

Radio will be extensively used in operations of the Great Northern Railway. First phase of the program involves Mesabi range iron ore transportation to the railway's ore docks at Superior, Wis. Equipment will permit constant radio contact between engineers and conductors, and between them and trackside stations. Railroad operators on the Cuyuna range are said to be acquiring similar equipment.

A gigantic cooling tower is being erected by the Colorado Fuel & Iron Corp., at its Pueblo, Colo., plant for use in cooling all water used in the operation of the power plant. The tower is 193 ft long, 63 ft wide, and 40 ft high. California redwood is the only material used for construction.

Conference on the evaluation and the long range use of the nation's resources, sponsored by Resources for the Future, Inc., will be held at Washington, D. C. during the fall. Lewis W. Douglas has been named chairman. The Ford Foundation has granted $150,000 to the conference.

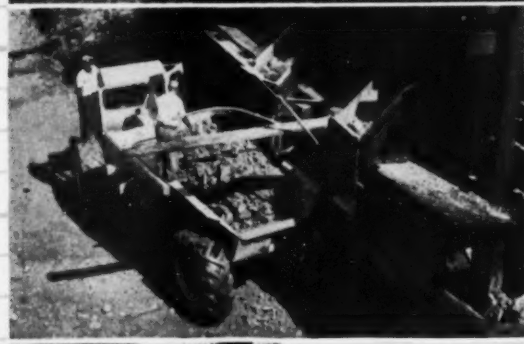
Joy Manufacturing Co. has acquired Barnes & Reinecke, Inc., Chicago engineering company, specializing in mechanical research and development. The firm will continue to operate under its present name and personnel as a Joy subsidiary.

Steel Industry negotiators can expect to sit across the table from United Steel Workers representatives any time after May 1, when present contracts allow wage provisions to be reopened. A guaranteed annual wage is almost certain to be one of the union's chief demands.

Canadian gold production in 1951 declined for the first time in six years, according to a report by the gold mining industry released by the Dominion Bureau of Statistics. Output fell to 4,392,751 fine troy oz valued at $161,872,873. This compares with 4,441,277 oz valued at $168,988,687 in 1950.

Jones & Laughlin Steel Corp. revealed that it can get 1.4 million tons of iron ore concentrates per year from its Benson mine operation at Star Lake in northern New York State. The figure represents about 20 pct of J&L needs at full operation. The corporation announced that additions at Benson will bring it up to 1.8 million net tons per year. Run-of-mine ore at Benson is about 17 to 25 pct iron.

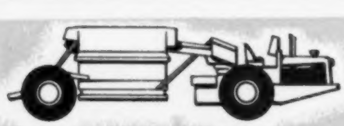
Can *your* rear-dumps match these performance records?



TOURNADOZER*
186 h.p., 4-wheel drive, speeds to 19 m.p.h.

TOURNAPULL*
7, 16, 27, 42-yd. capacities; speeds, 28 to 39 m.p.h.

TOURNAROCKER*
9, 18, 35, 50-ton rear-dump haulers



TOURNAHOPPER*
18 and 27-yd. bottom-dump haulers

CALIFORNIA MOUNTAIN QUARRY
tried 1 . . . bought 2 "C's"

Monolith Portland Cement Co. tried 1 C Tournarocker . . . liked it so well they bought 2 "C's" for hauling rock from the cramped quarters of their mountain-face limestone quarry. Working at an altitude of 3800', each "C" carries 16 tons per load . . . makes five 400' cycles every 50-min. hour.

INDONESIA TIN MINE
drives along narrow dikes

Constructing a network of dikes to get at underwater tin deposits, 3 D Tournarockers moved 11,000 yds. of sand monthly over 3-mile cycles. Much of haul was along narrow existing dikes. Performance of these 3 Tournarockers on this treacherous work earned an order for 16 more.

3,000,000-YD. PA. MINE JOB
dumps ½ min. faster than trucks

J. Robert Bazley Inc., Pottsville, Pennsylvania, strips overburden at their Mt. Carmel coal mine with 3 C Tournarockers. On 2100' haul, each "C" removes 15 bank yds. of sand, clay and rock every 7.4 minutes. With electric dump, fast spotting "C's" unload ½ minute faster than trucks.

WEST VIRGINIA COAL MINE
hauls 240 tons per hour

Red Parrot Coal Co., Prenter, uses a C Tournarocker to haul slate from refuse hopper to tailings dump. On 3000' cycle, "C", loaded with 15 tons, makes 16 trips per 50-min. hour. Output averages 240 tons hourly. With this production, "C" handles as much work as three 6 to 8-ton dump trucks.

NICARAGUA GOLD MINE
flies in "D" to haul ore

To reach isolated mine, 9-ton Tournarocker was cut apart and flown 110 mi. over jungle. Rewelded at job, it now hauls gold ore and waste to crusher. In typical month, it worked 356 hrs, moved 4698 tons. Hauls averaged 9800', all upgrade, with 9500' at 3 to 10%, 300' at 12 to 20%.

INDIANA LIMESTONE QUARRY
82,476 tons for 7.6c per ton

In 6 months, Dunn Limestone Co., Spencer, hauled 79,923 tons of rock plus 2553 tons of limestone and fluxing stone with 2 "D's". Total costs for 1,932 hours were $7,234 ($2760 wages; $3800 depreciation, insurance, taxes; $674 fuel, repairs.) That's $3.74 per hour or 7.63c per ton hauled.

ARIZONA COPPER MINE
40 tons every 11.2 minutes

Bagdad Copper Corporation, Bagdad, Arizona, owns 40 and 50-ton rear-dump Tournarockers. Cycle of 4500 ft. takes the units an average of 11.2 minutes, despite 650 ft. of 10% adverse grades and narrow winding haul roads. Cycle time includes 2 min. to load, ½ min. to spot and dump.

200,000-YD. W. VA. TUNNEL JOB
turns where trucks can't

Bates & Rogers Construction Corp., Chicago, teamed 2 D Tournarockers and 2 trucks to haul muck and shale for B. & O. railroad tunnel near Clarksburg. While trucks needed skid plate to turn inside 31' wide tunnel, "D's" made 90° turns (in 12'4" radius) and easily maneuvered under shovel.

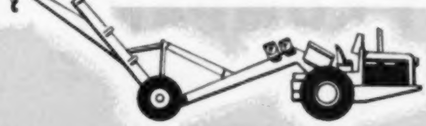
OHIO CLAY QUARRY
moves 100 tons of rock hourly

At U. S. Quarry Tile clay pit, Contractor Adolph Backus, Canton, hauls 100 tons of overburden hourly with his 122 h.p. D Tournarocker. Rig carries 9 to 9½ tons per load. Haul speeds average 14 m.p.h. over a 700' haul (which includes grades up to 20%), for a total of 11 trips per 50-minute hour.

PENNSYLVANIA COAL MINE
3 "A's" take place of 10 trucks

Colitz Coal Co., Pottsville, uses 3 A Tournarockers in place of ten 12 to 15-ton trucks. These big rigs carry 40 to 51 tons of overburden per load up 20% grades; over 2000' cycles, make about 50 trips each per 7½-hr. shift. Says Owner Colitz, Tournarockers have cut operating costs 40%."

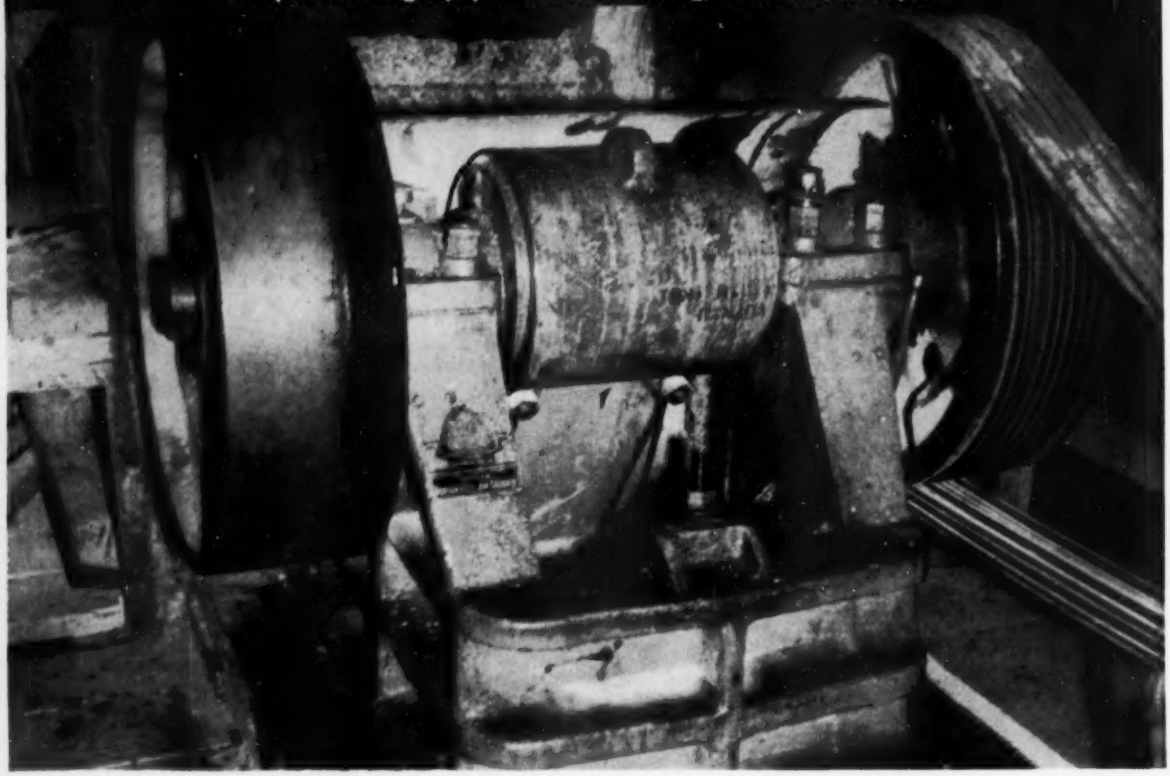
Tournarocker—Trademark Reg. U. S. Pat. Off. R-232-JS-w



TOURNACRANE*
10, 20, 30 and 40-ton lift capacities

R. G. LeTOURNEAU, INC.
PEORIA, ILLINOIS

*Trademark Reg. U. S. Pat. Off.



Bureau of Mines work at its Production Oil-Shale mine near Rifle, Colo., continues, with roof bolts surrounding this ventilation raise being driven at the operation. Other sections of the mine are also being roof bolted.

To Install Waste Heat Boiler at White Pine

White Pine Copper Co.'s smelter 18 miles southwest of Ontonagon, Mich., will have a six story high boiler utilizing what otherwise would be waste heat from a copper reverberatory furnace.

Designed and under construction by the Babcock & Wilcox Co., the boiler will supply steam to a turbo-generator furnishing power for the projected development. The boiler will be in line with and following the reverberatory furnace. Using waste heat from the furnace in place of fuel for steam generation, about 50 pct of heat in the fuel originally supplied to the furnace will be recovered by the waste heat boiler.

Exploration conducted over the past 15 years at White Pine, wholly owned subsidiary of Copper Range Co., has disclosed reserves of 309 million tons averaging 21.3 lb of copper per ton. Ore mineral is chiefly chalcocite (Cu_2S).

U. S. Buys Iron Ore From 17 Countries

Seventeen countries supplied the U. S. with 9,760,625 tons of iron ore during 1952, with 22 pct coming from Sweden. Chile, Venezuela, and Canada each supplied 19 pct of the imports.

Brazil sold 10 pct of the total imports to the U. S. while Liberia supplied another 6 pct. The 11 remaining countries supplied smaller tonnages.

U. S. Signs Huge Nickel Pact with Falconbridge

A contract calling for production of at least 100 million lb of nickel for sale to the U. S., beginning this year, was signed by Falconbridge Mines, Ltd., and Defense Materials Procurement Agency. The contract runs until mid-1962, with the possibility of obtaining an additional 100 million lb by mid-1967. Deliveries will start with at least 2 million lb this year. Howard I. Young, deputy Administrator of DMPA said the new Falconbridge project when added to new nickel supplies resulting from other contracts, and the large quantity of nickel produced by the Nicaro plant, will go far toward closing the gap between future supplies and estimated future requirements.

However, the new contract will not remove nickel from the critical list and still further production expansion will be sought. The U. S. will also receive significant amounts of cobalt under the contract—up to 2 million lb by June 30, 1962, and up to 52 million lb of refined copper by Dec. 31, 1958. Falconbridge is to deliver the 100 million lb of nickel by June 30, 1962 and the Government agreed to purchase an additional 50 million lb during the same period if offered.

Originally, Falconbridge did not intend to develop new discoveries of nickel-ferrous ore reserves for several years because of the large capital outlay required. Mr. Young stated that the company has agreed to go ahead with development because of the great need for nickel. The program will take an investment well over $42 million. The contract makes no provision for the advance or loan of any money.

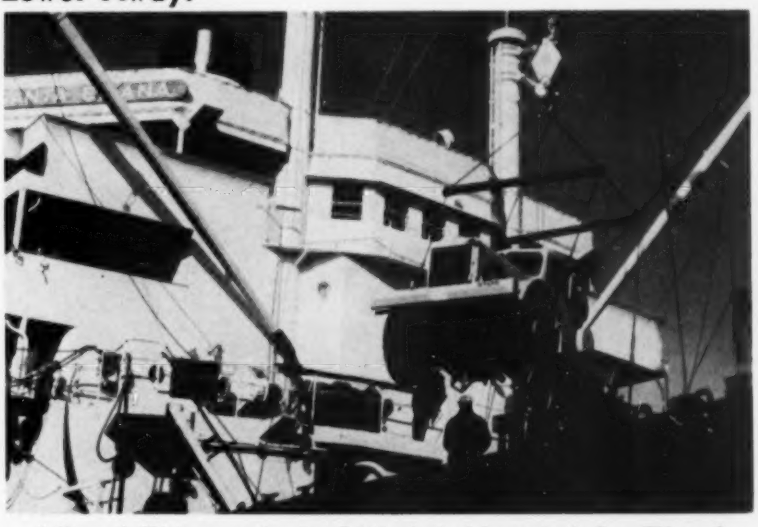
It will be a completely underground development. Two shafts, one of 3700 ft, and the other 3500 ft, will be sunk, along with several other shafts. Milling facilities will be installed and additional smelting and refining capacity provided.

37,626 Tons of Titanium Ore Produced at Lac Tio

Quebec Iron & Titanium Corp. deposit at Lac Tio, Quebec produced 37,626 gross tons of titanium ore in 1952. The mine is owned two-thirds by Kennecott Copper Corp., and one-third by New Jersey Zinc Co.

The company produces iron, steel, and titanium slag. Amount of ore produced was less than in 1951 because of the necessity of a cut back in mine production caused by a strike at the treatment plant lasting two of eight months of the mining season. However, more than twice the titanium slag produced in the treatment plant in 1951 was turned out in 1952, with nearly five times as much slag shipped.

Lower Away!



A Kenworth 524 is swung aboard at Seattle, destined for service in Peru. This truck and other Kenworth 524's will be operated by Miles & Sons Trucking Service between Utah Construction Co.'s Marcona iron ore project and the port of San Juan in Peru. Ore is rated at 60 pct or better iron content.

DRILLING *The Drillmobile has been leveled by its three hydraulic jacks. Operator at right is drilling a hole in a burn-wedge cut, while the operator at left is drilling a top relief hole.*

SLABBING *The jibs are swung back to line the machines for drilling outside slab holes.*

IN THE ROOF *The jibs can be raised and extended to drill a horizontal hole at a height of 15 feet.*

JOY . . . Since 1851—more than 100 Years of Engineering Leadership

Geophysical Exploration Grows in Japan

At the end of World War II, Japan's coal mining industry was in a sad way. War industry demands had forced an accelerated production schedule, allowing little or no time for exploration, development or maintenance. By 1945, production dropped to a little more than 22 million tons. In 1951 production had surpassed 43 million metric tons, topping both India and China, heretofore Asia's leading producers.

Most of Japan's iron ore has come from two mines, the Kuchan, in Hokkaido, and the Kamaishi, in Iwate Prefecture. Iron ore reserves, as released by the Japanese Geological Survey in 1950 amount to at least 44 million metric tons, with an additional probable reserve of 28 million and possible reserve of 98 million tons.

Japan, striving to regain its position in world industry, is undergoing an intensified effort to built its mining industry. Geophysical activity is increasing in the number and variety of applications in connection with exploration for metallic minerals, coal, ground water, and in respect to highway and other vital construction projects.

Seismic exploration for coal was conducted by the Japanese Survey in four areas last year. Offshore refraction methods were extremely successful in the Ube coal field, according to Kumiji Iida. Exploration was also successful in the Hichiku Plain in Kyushu where both refraction and reflection methods were used to work out the complex Tertiary and pre-Tertiary geology. Reflection surveys of potential oil structures brought results in the Hokkaido and Akita Prefectures.

Spontaneous polarization resistivity and seismic surveys disclosed a pyrite orebody, the Kusu mine, Oita Prefecture. The work was performed by the Japanese Geological Survey and was followed by drilling. Dowa Mining Co. located another pyrite deposit at the Yanahara mine, Okayama Prefecture, by resistivity and self-potential methods.

This coal mine in Kyushu is playing a large part in the industrial rebirth of Japan. Japanese coal production has increased in recent years, keeping pace with a growing steel industry.

Woman size coal at Yubari Coal mine, Hokkaido. Women represent a huge share of Japanese working force.

The self-potential method was used by the Ishiwara Mining Co. to locate the copper orebody at the Myohho mine, Wakayama Prefecture. The same method was utilized by the Sumitomo Mining Co. in exploring underground workings of the Yoichi mine, Hokkaido, for lead and zinc.

A number of electrical and magnetic surveys have been made for iron, tungsten, and sulphide deposits at various mines in the Tohoku, Chubu, and Tyugoku regions. They are being checked by drilling.

Refraction seismic and resistivity methods were used extensively for locating ground water and in connection with a variety of engineering problems. During 1952, some 120 ground water geophysical surveys were made.

Increasingly portable seismic and electrical field equipment is being developed and is aiding in mineral development. Electric borehole methods are also receiving considerable attention. The trend is more and more toward improving the accuracy and efficiency of field surveys.

Studies to determine the relations between time changes and the gravitational field, ground subsidence and seismic activity were made near Kyoto and Osaka. The new Usu volcanic area was the scene of gravity, magnetic, electrical, radioactivity, and geochemical surveys made to gain information on sources of geothermal energy.

Freeport Sulphur Discovers Nickel at Moa Bay, Cuba

Exploration Discloses 40 Million Ton Reserve

Freeport Sulphur Co.'s disclosure of a large and significant nickel orebody in Cuba comes at a time when the supply of nickel is definitely short of U. S. defense requirements and civilian users are on a severely restricted allocation basis.

Freeport's extensive exploration program revealed the existence of at least 40 million tons of nickel ore in the Moa Bay area, about 500 miles east of Havana. Company officials termed the deposit the most important proven source of nickel anywhere in the world—except for certain Canadian deposits.

While Freeport developed a treatment process for the Nicaro Nickel plant in Cuba, U. S. Government-owned installation operated by a Freeport subsidiary during World War II, it will not be used for the Moa Bay ores. According to John Hay Whitney, Freeport chairman:

"The Moa Bay ores can be readily treated by the process developed by Freeport for the Government plant. However, as a result of extensive research on lateritic ores, Freeport has developed a new and better leaching process involving the use of sulphuric acid.

"Chemical Construction Co., a subsidiary of American Cyanamid Co., has also made important progress in the treatment of nickel and cobalt ores. Among their developments is a process for the production of nickel as a metal rather than oxide and also of cobalt metal."

A combination of the sulphuric acid leaching process and Chemical Construction's metals techniques represent an improvement over present Nicaro practice, according to Freeport thinking. MINING ENGINEERING, June, 1952, carried a detailed story of the Chemico process.

"Freeport and Chemical Construction have concluded an agreement to collaborate in this field."

Freeport plans to build a pilot plant to obtain engineering information for design of a commercial plant to treat Moa Bay ores. While the company intends active pursuit of plans for commercial plant production, it was noted that it will probably be years before such an undertaking will make significant contribution to the company's distributable earnings.

Freeport was the first U. S. firm to mine and process nickel on a large scale, and in the past has been responsible for development of new methods for recovery of nickel from ores previously considered unusable. The deposit at Moa Bay, according to Mr. Whitney, averages about 1.35 pct nickel and approximately .14 pct cobalt. He added that the orebodies are larger and more valuable than those now supplying Nicaro. Reportedly company financed, the program is expected to grow into the production stage by 1955 if all goes well. Smelter location is undecided.

Freeport Sulphur employees operate drill during exploration program which disclosed some 40 million tons of nickel ore in the Moa Bay area of Cuba, 500 miles from Havana, on the northeast coast.

During a recent meeting with magazine and newspaper editors, Mr. Whitney, in pointing out the significance of Moa Bay said:

"The whole military defense effort rests primarily on two things—jet planes and atomic bombs. In both of these programs nickel is vitally essential. For example, in some instances a single jet engine requires as much as 24 pounds of nickel."

Latest Defense Production Agency expansion goal figures call for 380 million lb in 1955. Free world nickel

Chemical Construction, Freeport Sign Agreement

production in 1952 amounted to some 315 million lb. Simple arithmetic indicates that the U. S. goal is about 65 million lb more than presently available to all free nations.

More than 90 pct of the nation's nickel supply is currently going to defense—only 8 pct finds its way into civilian channels. Yet, according to DPA the 202 million lb supply in the U. S. during 1952 was not enough for defense needs.

Civilian consumption of nickel averaged 160 million lb during the years 1946 to 1949. When that figure is added to 202 million plus, needs of defense, the total is nearly 400 million lb—about twice the current supply. And this figure does not account for stockpiling requirements.

The Senate Small Business Committee, after a number of hearings held during 1952, concluded that requirements of Free World countries are something like 200 pct of the available supply.

Freeport Sulphur, in tying in the Moa Bay discovery to the world trend in nickel, points out that the Cuban deposit is within safe and reasonable distance to the U. S. during any emergency period. Langbourne Williams, Freeport president, also points to previous good relations with General Batista.

General Batista, in a statement made by Andres Domingo, secretary of the presidency and a member of the cabinet, noted his pleasure in the prospective pilot plant and recalled Freeport's previous Cuban ventures.

Moa Bay area is covered with a dense tropical growth under which lies what Freeport officials call the most important source of nickel outside of Canada. Pilot plant to be constructed at this site will give data for recovery of nickel as well as cobalt.

RFC, Hochschild Watch Patino Bolivian Talks

Reconstruction Finance Corp. officials are watching negotiations between the Patino mining group and the Bolivian Government for signs of an agreement concerning payment for the nationalized tin mines. It was reported in Washington that if an agreement between the two parties goes through it would remove another barrier to resumption of tin purchases from Bolivia. A preliminary agreement is reported indicating some progress has been made on the problem of payment. Part of the tin sales by the Bolivian Government from former Patino mines will be retained for ultimate application to a purchase price for the nationalized properties.

It is also reported that a number of points in the agreement were left for final settlement during the next few weeks. Price to be fixed is one of the matters to be determined.

RFC intentions to buy Bolivian tin depend on whether a satisfactory price for tin can be reached. The State Department has been actively attempting to gain some compensation for the expropriated mines.

In the meantime, Hochschild mining interests, whose mines were also seized by the Bolivian Government, watched developments. A spokesman stated that the firm welcomed any move in the direction of a genuine solution of the compensation problem.

"We are distinctly more encouraged and earnestly hope that the possibility of a complete settlement for all of the companies and their stockholders, regardless of nationality, whose properties were expropriated will be eventually carried out."

Allen Mine East Portal in Production

East portal of Colorado Fuel & Iron Corp.'s Allen mine is producing coal, A. F. Franz, CF&I president announced. Coal production from the west portal started last year and has been increasing steadily.

Work on the east portal, about two miles from the west portal, started later. Recently the conveyor belt serving that part of the mine was placed in operation. The conveyor takes the coal from the east portal, through a giant Bradford breaker, and then to loading chutes above the CF&I Wyoming railway tracks where it is loaded into cars. Cars holding 60 tons of coal can be loaded in slightly more than 10 min.

Coal is brought from the west portal in cars and dumped into chutes carrying it to the breaker and the railroad cars. All coal is shipped to CF&I's integrated steel works at Pueblo.

CF&I has three major mines producing in Las Animas County, Colo. In addition to the Allen mine there is the Morley mine and the Frederick mine at Valdez.

Manganese Research Begins on Wad Ores

Search for a method to economically convert low-grade domestic manganese ores to a usable product has been widened to include so-called wad ores of New Mexico and Arizona, according to Defense Materials Procurement Agency.

Under a contract between DMPA and Southwestern Engineering Co. of Los Angeles research is now underway on Virginia and Arkansas wad ores and Aroostook manganese deposits in Maine. The contract has been extended to include similar studies in New Mexico and Arizona.

U. S. consumption of manganese is upward of 2 million tons yer year, with only about 10 pct coming from domestic sources.

AEC Information Maps Posted on April 15

Four additional offices have been named for posting of location maps containing site of surface areas of high radioactivity.

Beginning April 15 and on the 15th day of each following month, or the first succeeding work day if the 15th falls on Saturday, Sunday, or holiday, index maps will be posted at noon, Mountain Standard Time, at the following AEC offices:

Albuquerque Sub-Office, Professional Bldg., 142 NE Monroe St.; Douglas Sub-Office, 209 East Center St., Douglas, Wyoming; Phoenix Sub-Office, 614 Goodrich Bldg., 14 North Central Ave., Phoenix, Ariz.; and the Ishpeming Sub-Office, Room 2, Post Office Bldg., Ishpeming, Mich.

M. A. Hanna to Boost '53 Iron Ore Output

M. A. Hanna expects to boost iron ore production some 33 pct during 1953 to 19 million tons from the 14,356,740 last year. Progress is reported on the Labrador-Quebec iron ore project.

About 230 miles of railroad track remain to be laid, but between 60 and 70 pct of the grading ahead of the line has been completed. J. H. Thompson, Hanna president, said, "it is hoped that we will start shipping iron ore from the region in the fall of 1954. This is the same schedule as a year ago."

The Iron Ore Co. of Canada, Labrador-Quebec operating organization in which Hanna and six steel organizations have an interest, has "reasonably proven" reserves of 417 million tons of ore. Efforts are being made to prove additional areas of ore.

Climax Aims For 25,000 Tons Per Day

Climax Molybdenum Co. expects to be in a position to mine and mill 25,000 tons of molybdenum ore per day by the end of 1953, and to process residues from all ores mined up to 20,000 tons per day in the by-product mill.

It also opened the new Storke Level for mining and is preparing enough ore for capacity production. MINING ENGINEERING, January 1953, carried a complete technical description of the Storke Level operation at Climax.

Company earnings for 1952 reached $6,071,519, compared with $7,964,169 in the previous year. The company noted that its contract with the Government assures operations at a 20,000 ton per day capacity until 1956. Another Government contract provides for mining and treatment of an additional 5000 tons of low grade ores per day extending until 1962.

Nicaro Nickel Plant Gets Sinter Equipment

It is expected that the new sintering equipment to be installed at the Government-owned Nicaro nickel plant in Cuba will pay for itself in three years, according to W. E. Reynolds, of General Services Administration. Nicaro now produces a powdered nickel oxide, which can be used only by electric furnaces unless packaged in heavy metal containers. The sintered product will be worth 2¢ more than powdered oxide. Equipment will cost about $750,000 installed and will be in operation in approximately eight months. Frederick A. Snare Corp., New York, the firm that built the original plant and put it back into operation, will install the equipment. The plant was closed after World War II.

While the sintered product can be used in both electric and open hearth furnaces, a small quantity of oxide will be produced for a number of processes where it is preferred. It also has other special uses.

Research to develop a process and product suited to the industry demand were carried out by Nickel Processing Corp., American-Cuban firm operating the plant for the U. S. Government.

Oliver May Build $60 Million Plant

Oliver Mining Co., U. S. Steel Corp., subsidiary, is contemplating construction of a $60 million iron ore beneficiation plant at Two Harbors, Mich. Engineering studies are in progress.

Oliver is meeting increasing moisture content in run-of-the-mine ore and the new plant is expected to eliminate the difficulty. The company is now operating iron ore treatment plants at Virginia and Mountain Iron, Minn.

To Develop Chrome Mine with Govt. Backing

Development of the Red Mountain chrome deposit on the Kenai Peninsula, near Seward, Alaska, will be underwritten by the U. S. Government, according to an agreement with the Kenai Chrome Co.

The Government has agreed to buy 13,000 long tons at $97 per ton. Defense Materials Procurement Administration announced it will advance Kenai $200,000 for working capital and $110,000 for opening the mine and installing a loading dock and other facilities.

Ore will be mined during the summer for shipment to Seattle or Tacoma, Wash. Specifications call for 13,000 tons to be 48 pct ore with a chrome-to-iron ratio of three-to-one. Six thousand tons of ore were mined in the same area during World War II but were never shipped because of lack of loading facilities.

DMPA Withdraws From Fad Mine Rehabilitation

Defense Materials Procurement Agency has withdrawn from its agreement to participate in the rehabilitation of the Fad mine of Eureka Corp., Ltd., in Nevada, according to President Thayer Lindsley, of Eureka.

The mine shaft has been flooded for several years. A report is expected soon from independent consulting engineers and the Cementation Co., of London, employed in studying the water problem. Mr. Lindsley stated that work already done and geological structure indicate larger tonnages of good grade lead and zinc than have been revealed to date. He went on to state that it is felt that every effort should be made to open up the indicated orebodies. Exploration work is also being carried on in the Adams Hill section of the property. A drilling program will start soon.

AN indication that Mesabi Range iron ore companies may develop their own flotation processes for low grade iron ores is the report that Cleveland Cliffs Iron Co. is adopting a variation of one of the oldest known methods at its new Michigan treatment plant. Basically, the method involves using fatty acids and fuel oil reagents. The idea was developed many years ago and should be free of patent control. With other laboratories working on the same tack, it seems to be a pretty good bet that they will come up with their own processes. Any outside process will have to offer considerable advantage or low royalty rate to get consideration.

Much of the appeal of the fatty acid process is the cheapness of the reagent. One source is pulp paper liquor in semi-refined form. With stream pollution legislation acting as a strong pressure, paper companies have been seeking ways to dispose of the material. Wisconsin has even attempted to use it for road binder.

No definite beneficiation plans for taconite and other low grade ores have been fixed, but roasting prior to grinding is getting a good deal of attention in some quarters. When roasting is carried out *before* grinding the grindability index is changed and lowered grinding costs pay for part of the roasting. Conversion of non-magnetic fraction of magnetite ores raises recoveries and the possibility of simple magnetic concentration of entirely non-magnetic ore offers an advantage for such a flowsheet. Thus, flotation may be ruled out entirely.

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MANY of those who understand the economics of coal production feel that the problem of transportation costs will be a vital factor in determining the survival of the industry in the U. S. Unless something is done to make the carrying of coal from the mines to its point of use cheaper than it is today, the industry will be constantly on the defensive. One coal executive claims that transportation costs make up almost half of the delivered cost in some extremely competitive markets. Until now, the obvious means of transportation for coal has been the railroads. Now, after several years of closely guarded experimentation, Pittsburgh Consolidation Coal Co. has announced that it is ready to begin building a coal pipeline. Tests were conducted in Eastern Ohio and proved successful, according to the company.

Right now, Pittsburgh Consolidation is busy lining up potential customers for a proposed pipeline to haul coal from Southeastern Ohio to the south shore of Lake Erie—about 110 miles. It would go to utility companies in Buffalo, Cleveland, Detroit, and other western points. Coal would be crushed, made into a slurry, and forced through the pipeline by pressure pumps. At the end of the line it would be dried and readied for use.

The company says:

"After eight months operation, the experimental pipeline project in Ohio had provided sufficient data to satisfy us that transmission of coal by pipeline can be developed economically. The pipeline product is essentially coal in a new form and we are now proceeding to develop the commercial aspects of providing sales outlets for it."

Detroit Edison, buyers of some Consolidation coal via rail shipment, says there have been talks concerning a contract for coal to be carried by pipeline. "We're interested in anything that would conceivably knock our freight rate down." Cleveland Electric Illuminating Co. also has expressed interest in the project. Some sources have predicted that a coal pipeline from Cadiz, Ohio could carry coal to the lake area for about $1 per ton less than the railroads charge. The railroads get about $2.75 per ton with a 12 pct increase pending.

Experiments performed on the experimental line at Cadiz moved a slurry of crushed coal and water some 17,000 ft under pump pressure. Engineers believe it will work cross-country, but others preface remarks with a few "if" statements. It will take two years to build the line and as yet no construction date has been set.

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ZIRCONIUM, rated right behind uranium in importance in the construction of the long heralded atomic submarine, will be produced on a "full commercial scale," by Carborundum Metals Corp., according to Westinghouse Electric Corp. atomic scientists. In 1949 two-lb pieces of zirconium were experimented with under laboratory conditions. Today, industry is forming, rolling and machining parts from ingots 1-ft diam and weighing up to 500 lb. Considerable pilot plant work was done in 1951 and 1952 and with increased Atomic Energy Commission requirements the Bureau of Mines began production of the first commercial size ingots. The AEC recently announced that it has signed a contract with Carborundum for a 5-year order of zirconium sponge at less than $15 per lb. At the beginning of the Westinghouse submarine reactor project, zirconium sold at $250 per lb.

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A BILL providing for inspection of metal and nonmetal mines is currently making the rounds in Washington, but according to various sources, is not meeting with much acceptance. The bill is rumored to be the product of the United Steel Workers and would extend the provisions now covering coal mines to the rest of the mining industry. It would not, however, include the right of federal inspectors to shut down mines.

If the bill is passed, it will give the Bureau of Mines the right to make annual or necessary inspections in metal and nonmetal mines and quarries to obtain information relating to health, safety conditions, occupational diseases, and accidents. Based on findings, the bureau would then be permitted to propose legislation. Failure to admit federal inspectors could cost mine operators $500, and 60 days im-

prisonment. Owners would have to, upon request, supply information on accidents resulting in bodily injury or loss of life. Three mine labor representatives and three owners would compose an advisory board appointed by the Secretary of the Interior. The Committee, cooperating with the Mines Bureau would then "promulgate a code of reasonable standards and rules pertaining to safety and health conditions . . ."

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IT'S still much too early to tell, but there is a strong possibility that the United Steel Workers, CIO, and the Mine, Mill and Smelter Workers may meet head-on sometime in the near future. David J. McDonald, elected to a four-year term to succeed the late Philip Murray, said in his inaugural speech:

"Anywhere in America where metal workers are not organized, we'll be there."

Referring to organizational efforts, Mr. McDonald said he didn't want members of the union to "come crying to me about intrusion of other unions into our jurisdiction. Let the other unions do the crying. I'm not talking about raiding. I'm talking about organizing the unorganized."

Taking into account that Mine and Mill is intent upon expanding its membership in the near future, it may prove to be a rather interesting summer. The USW head also made mention of unorganized workers in Venezuela, Guatemala, and Jamaica. Not too long ago Mine and Mill had occasion to announce tentative plans for organizing outside of the boundaries of the U. S.

Primary attention will be given to the West by the USW, according to Mr. McDonald. The union already has some representation in that region and is in direct competition with Mine and Mill, at one time a member of the CIO but expelled because of "Communist domination."

It may be that Mr. McDonald seeks to increase the size of his union because he is not fond of heading the second largest union in the CIO. Right now, the Auto Workers outnumber the steel workers. Reports on the internal condition of the CIO indicate that there is some jockeying for power going on.

If the reports are even partially true, the next few months should see some rather interesting situations developing both externally and internally.

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CONGRESS received four proposals for laws which would impose a sliding scale tax on imported lead and zinc. The four bills were in virtual agreement and are based on recommendations presented by the Emergency Committee on Lead and Zinc last February in Denver. Introducing the bills were Rep. Richard M. Simpson (R-Pa.), Rep. William A. Dawson (R-Utah), Rep. Douglas R. Stringfellow (R-Utah), and Sen. Henry C. Dworshak (R-Idaho).

Additional duties on lead and zinc would be imposed when the market price of the metals fell below the adjusted base price. The Emergency Committee suggested a base price of 15.5¢. Adjustments would be made in the base price in line with the average market price as determined by the Treasury Department—with the middle month of each quarter the determining factor.

Additional duty on lead and lead pigments would be one cent per pound plus an amount per pound equal to the amount by which the adjusted base price of common lead for the quarter exceeds the domestic market price of common lead for the quarter.

In the meantime, despite depressed lead and zinc prices and declining net returns, producers in the Coeur D'Alene area are continuing with expansion programs. Sunshine Mining Co., for example, increased its known ore reserves to 997,000 tons in 1952 with a program of diamond drilling. Development continued on a large scale with drifting, raising, crosscutting, and sinking totaling 7126 ft. Diamond drill holes totaled 2517 ft. Bunker Hill & Sullivan Mining & Concentrating Co. reported ore reserves totaling 2,975,485 tons, higher than at any other time in the past ten years. Many mining companies reported their mills working on curtailed schedules, however.

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WITH about 60 pct of the world's asbestos production coming from Canada and the almost obvious fact that demand for what the Indians call the "rock with hair on it" is certain to increase, there has been a concerted effort to expand known sources of supply. More than 1 million tons of asbestos was used last year in roofing, siding and floor tiling for homes, for fire-safe ship interiors, and theatre curtains, acoustical paneling and many other places in home and industry.

Estimated world production in 1952 was 1,439,000 tons, almost doubled since World War II. Prices have gone from about $700 during the war to between $1100 to $1500 for crude No. 1, the best grade of asbestos. Large producing companies are spending huge sums on exploration programs aimed at providing reserves for years to come. While most of the firms are confining exploration to the Western Hemisphere, at least three—Johns-Manville Corp., of New York; Turner & Newall, Ltd., of Manchester, England; and Cape Asbestos Co., of London—have been searching the globe.

Johns-Manville has developed a third mine in Africa supplementing production from the company's two Canadian enterprises. The African mine is 200 miles south of Salisbury in Southern Rhodesia. A 20,000-ton capacity mill is under construction. Johns-Manville is also exploring a primitive section of the Department of Antioguia, Columbia. Diamond drilling crews are already at work.

Drift of Things

TOO early spring may be the explanation for the poor turnout of mining and metallurgical engineer candidates at a large New York guidance conference, but it would be wiser to take a more serious view of this occurrence. Held a few weeks ago, the meeting was preceded by weeks of preparation and publicity in which many engineering societies participated. The meeting was the First Greater New York University downtown campus for splitting up anticipated to draw about 20,000 high school students from the New York area and environs. Seven of the theatres in the Paramount chain were available to hold the audience for a panel program on career opportunities which was to be televised and piped into the theatres. Following the morning theatre session, students were to adjourn to the New York University downtown campus for splitting up into workshop sessions devoted to seventeen different branches of the profession.

The day of the meeting dawned sunny, clear, and unseasonably warm. Attendance in the morning reached 2500, about one eighth of expectations, and dwindled to about 1100 in the afternoon as the good weather took its toll. Paul Lange, who was counseling mining, told to prepare for 100, found four students at his meeting room. George Kehl had seven at the metallurgy workshop of whom it appeared three were in the wrong pew being chemical engineering aspirants. This seems like pretty lean pickings for the mineral industries when the electrical, chemical, and mechanical groups each drew hundreds.

Mineral industry people connected with the conference were disturbed by this outcome of the meeting. They pose the question of whether or not this condition pertains throughout the country. From where we sit considerable evidence has come to hand to indicate that an apathy does exist among the nation's young people toward the mineral industries with the possible exception of petroleum.

Metropolitan areas represent our largest reserves of potential engineer-power. But here industry is obscured by being located in parts of town where school children seldom go or in such a haze of industrial grime as to be unattractive. With this bleak facade, which is usually associated with engineering, coupled to public ignorance of what engineers are, the profession is bound to suffer in engineer recruitment.

Our industry is the least known and has lost out in the glamour contest to electronics, nuclear science, rocket engineering and even industrial engineering. We excepted petroleum earlier because it evidently still has an aura of quick riches.

No outpost should be deserted by the simple thought that you wouldn't expect to find people interested in mining and metals in the New York area. They aren't interested because they don't know and it would be suicide to sit back and wait for the young people from the mining and smelter towns to fill the ranks.

In the March *Drift* we described what some are doing to publicize engineering and as a starting point for those who think the situation serious enough, we suggest an extension of these programs.

LAST September MINING ENGINEERING carried a news item about a \$3.8 million loan by Defense Materials Procurement Agency to Westmoreland Manganese Corp. for mining and concentrating manganese deposits near Batesville, Ark. Westmoreland was to increase annual domestic production of manganese by 52,800 tons by concentrating low grade ores by the sink-float process at the rate of 6000 tons of raw feed per day to produce 240 tons of high grade manganese. The company put up \$775,000 of its own money.

A recent clipping from a Batesville paper indicates that the operation is shut down before completion of the plant or opening the mine, the company having exhausted its funds. According to DMPA spokesmen that agency is not disposed to advancing more money.

Apparently this outcome might have been anticipated from the start if DMPA had looked closely enough at the project before okaying the loan. Before the end of September we had received a copy of a letter from Charles S. Blair of Birmingham, Ala., to Jesse Larson, administrator, DMPA. Mr. Blair wrote: "... Based on a somewhat intimate personal acquaintance with the Batesville, Ark., district and its manganese resources from World War I days, we are at a loss to understand the basis for such a tremendous loan to a relatively new and inexperienced company in this old and greatly depleted manganese field.

"... The output of high grade ore from the Batesville field has always been limited reaching only 7000 to 8000 tons during 1917 and 1918 and in about the same amount in 1944 and 1945 with the output declining to almost zero during the intervening years. The output in 1948 was recorded as 212 tons.

"... The high grade ores occur in residual clays, usually close to or even at the surface, and the entire field has been closely prospected by thousands of test pits and surface workings from which the ore production up to date has come, the miner screening out and recovering the ores from the clays in the same manner as the individual farmer does his potatoes from the garden.

"... This field has always included a large number of both purely speculative and important mining companies, some well financed, who have designed and built many various types of mechanical concentration plants, all of which have been entire failures due principally to the small tonnage available at any one locality.

"... As a matter of personal interest, I have asked Dun & Bradstreet for a financial report on the Westmoreland Manganese Corp. from which I quote:

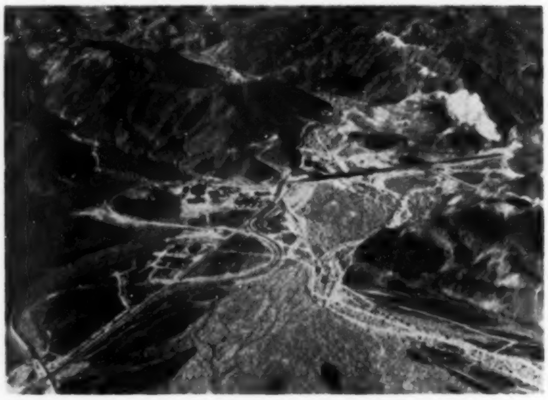
'Holdings are stated by management to consist of 3000 acres of ore-bearing land owned outright with an additional 1450 under option for lease. Mine and process manganese ore. Equipment consists of one bulldozer and miscellaneous small mining equipment.' "

DMPA says it is not even considering putting any more money into the project unless the company can "show a better performance, including getting some money of its own."

John V. Beall

Benches cut into Eagle Mountain supply iron ore to keep steel flowing from Kaiser's Fontana steel works.

RIGHT: Aerial view shows rugged terrain at site of Kaiser mining operations. Railroad in left foreground snakes 51 miles to Ferrum and junction with SP for trip to Fontana. Brand new town is at center and the mine itself is in upper right. Photographs below show two typical and vital operations in this all truck pit.



LEFT: Churn drill putting down 9-in. blast hole. ABOVE: Four Bucyrus-Erie electric shovels load fleet of 20 trucks with average 13,930 tons per day.

Eagle Mountain Helps Kaiser Meet Growing Western Steel Needs

by Kenneth B. Powell

EIGHT years ago the Eagle Mountain iron ore deposit located in the hills of the Colorado Desert in the extreme southeast part of California was known only to a few geologists, mining men and the oldest of the desert prospectors. Today, the deposit is the Kaiser Steel Corp.'s Eagle Mountain Mine, and the once lonely hills now shelter a model community of 225 people enjoying all modern conveniences. Nearest town to the mine is Indio, 60 miles distant by an excellent highway. Elevations at the deposit vary from 1400 to 3000 ft.

The mine enjoys winter resort weather between October and May with occasional drops to 25° at night. From June to September temperatures rise to 120° at times. Rainfall is scant, approximately 2 in. per year, the majority of which comes during the summer months as cloudbursts.

The property produces all the blast furnace ore requirements for the Company's Fontana, Calif., plant. Current production is 1½ million tons per year, which will rise to 2¼ million tons early this year after the completion of a third blast furnace.

Mining Plan

Current operations are on two orebodies, the North and the South, which will be mined in one pit. Mining started in July 1952. It has been noted that the orebodies dip at approximately 45°. The hard dense ore has withstood erosion, and consequently, forms the back bone of ridges, while the adjacent softer waste materials have eroded more. This situation has made it possible to evolve a most economic method of mining. Twenty benches, each 30 ft high have been established. These 20 benches will provide for the mining and stripping of the two orebodies from the apex at 1760 ft elevation to the bottom of the pit at 1110 ft elevation. The gravel talus surrounding the orebodies is 1380 ft elevation at the west end and 1110 ft elevation at the east end.

A truck haul road 70 ft wide has been built on a 7½ pct grade from the west end to the top bench elevation at 1710 ft. The primary crusher, a 66x84-in. Buchanan jaw type, has been located at 1500-ft elevation. During the life of the pit, the crusher will be moved twice; to 1350-ft elevation and to the 1200-ft elevation. Relocation of the crusher will be justified by savings in length of truck hauls.

The ore crushed to −10 in. for shipment is conveyed to a 75,000-ton stockpile on the 1380-ft elevation located at the west end of the pit and outside the pit limits. The stockpile remains in this one position for the life of the pit despite crusher relocation.

Ore for shipment is moved from the stockpile by a 1500-ft conveyor to a railroad car loading bin. A pan feeder located in a reclaim tunnel controls the belt loading.

Mining operations were started on the top bench where the haul road crossed the bench elevation. In laying out the haul road, it was planned so that the top 10 benches would intersect the bench elevation within the pit limits. Three benches will be mined simultaneously and work on each will be timed to the requirements of ore and the need for stripping. Work on each new bench is started at the intersection of the road and the bench elevation.

Ore will be trucked down grade to the crusher from all benches, except the last three of the total 22. Waste will be trucked down grade to waste dumps or level across benches to footwall dump. It is anticipated that maximum hauls from any one bench will be 3000 ft.

Slope of the stripping wall is set at ½ to 1. As an added safety protection, a 30 ft wide berm is left every third level (90 ft). The berms given an overall stripping slope of 52°, and in addition they serve as a catch for falling rock.

The mining plan developed a most favorable stripping ratio: 1 ton of waste to 1 ton of ore. Included waste within the ore zone has been considered a part of the overall stripping ratio. With the exception of the four top benches and the three bottom benches the stripping per bench is within 10 pct of the 1 to 1 ratio. On these seven benches the stripping is well below the overall ratio.

Drilling and Blasting

Primary drilling, which represents approximately 90 pct of all blast hole drilling, is done with churn drills. Nine-in. holes 36 ft deep are drilled on an average pattern of 14 ft burden and 14 ft spacing. All drill holes are cased with 6 to 10 ft of 10-in. pipe to prevent collar spalling. The drill pipes are salvaged for re-use as the blasted material is loaded

KENNETH B. POWELL is superintendent of raw materials, Kaiser Steel Corp., Fontana, Calif.

EXPLORATION

Kaiser Steel Corp. is currently mining and will continue mining in the extreme east end of the property for many years. A well defined seven step exploration and development program has been completed in this area. The same sequence will be repeated several times in the future to develop the balance of the orebodies.

1. The entire property lies in unsurveyed territory and is long and extremely narrow. Consequently, a triangulation system of primary and secondary controls was set up. This system tied into Lamberts North American Grid and is checked into a carefully measured base line on the property.
2. A geological topographic map was evolved for each orebody. Control for the mapping was a base line along the strike of the outcrop. Cross section lines at 100-ft intervals were established at right angles to the base line and closed to the same. The base line in turn was tied to the triangulation system. Stations were set (approximately 50 ft) on the section lines which were projected well beyond the foot and hanging walls of the ore. All contacts, faults and dikes were shot in. Elevations by vertical angles were carried in all this work. Due to the complexity of the surface geology, a great amount of control work was required. By the time it was completed, sufficient data was available for well over half of the topography. The blind spots were filled in by areas until the topographic map was completed.
3. The surface outcrops were sampled at five-ft intervals in trenches cut on each section line.
4. A magnetometer survey was run using the already surveyed and staked mapping grid.
5. A comprehensive diamond drilling program was carried out. Drilling was done from the surface and from a 3000-ft tunnel driven along the strike of the orebody approximately 400 ft below the apex. Drill holes were held to section lines in most cases. Both core and sludge samples were taken in the ore zone and the results correlated using Longyear tables based on the percentage of core recovered. Actual weights of core recovered by drill intervals were used to determine the percentage of core recovery.
6. A series of sections were developed, using all data accumulated from the mapping and diamond drilling. Grades of ore were shown thereon by zones.
7. Finally, a mining plan was developed, showing:
   (a) Outline of the pit.
   (b) Bench elevations.
   (c) Grades and tonnages of ore by benches.
   (d) Tonnages of stripping and included waste by benches.
   (e) Waste disposal areas.

out. Two sizes of drills are in use—Bucyrus-Erie 29 T's and 42 T's. Drilling speeds are 6 ft per hr and 10 ft per hr respectively. Bit changing, moving and set up times are included as time drilled, but not down time for repairs. Overall cost for drilling is \$0.90 per ft.

Holes are loaded with 40 pct nitro starch, slow speed bag powder, 5800 to 6500 fps. Seventy-five pct stick powder is used as a primer which is detonated by electric millisecond delays. Millisecond delays have proven very satisfactory in the elimination of concussion which in turn has cut the hazard of falling rock from the stripping wall side of the pit. The powder factor based on the past 6 months period is .37 lb of powder per ton of all material blasted. The 29T drills swing a 3600-lb string of tools using a 20-ft stem, and the 42T drills swing a 5000-lb string of tools using a 30-ft stem. A drilling practice worthy of note is the fact that a two joint stem is used on the 42T's. A 10-ft stem is on top and 20-ft stem on the bottom. One 20-ft section will wear out two 10-ft sections, thus making a saving in replacement costs over the use of a one piece, 30-ft stem. A minimum of pin or box trouble has been encountered.

All churn drill holes in ore and contact material are sampled as drilled. As the dart valve bailers are emptied in the anvil box, a cut of the run off sludge is made which flows into a container. The resulting samples are used as a guide to control grade.

Secondary blasting is at a very minimum, due to the fact that ore and waste are, for the most part, highly fractured. Jackhammer holes and stick powder detonated by electric caps are used for this purpose.

Jackhammer and wagon drills are used only when new benches are being established and for road work. As this represents only a limited amount of drilling, portable compressors are used.

Alloy detachable bits are used for the majority of pneumatic drilling. These are hot milled and retempered by a custom shop for re-use. A small supply of tungsten carbide bits is maintained for use when extremely hard ore or waste is encountered.

Geological History

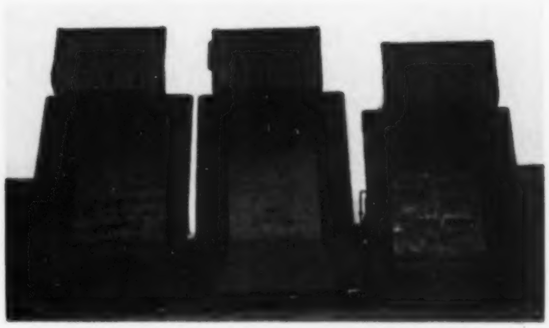
Iron ore occurs in a series of over 60 orebodies in a mineralized zone in metamorphic sedimentary rock that varies from ¼ of a mile to 1¼ miles wide, and extends over 6 miles in an east-west direction across the northern part of Eagle Mountain.

Here the oldest formation consists of gneiss, schist, and quartzite, with local thin layers of crystalline limestone. Next younger is the thick series of metamorphic sedimentaries, the lower part of which consists of massive vitreous quartzite with thinly bedded and schistose felspathic layers. The upper part includes crystalline dolomite, quartzite, schist, lime-silicate rock, iron ore and various metamorphic minerals in lesser quantities. These sedimentaries have in turn been intruded by bodies of quartz monzonite.

The iron ores with associated metamorphic minerals, serpentine, mica, epidote and pyroxene occur as complete or partial replacements in the dolomites and in some cases the impure quartzites.

Following the mineralization, a period of uplifting and tilting occurred, accompanied by considerable faulting, which caused vertical displacements of the sediments (including ore beds) as great as 300 ft. Still later, fine grained dikes up to 25 ft in width were intruded, many of which cut the ore formations.

Down grade hauls require maximum braking capacity. All trucks have Hydrotarders mounted on drive shaft, speeds can be held to safe 9 to 15 mph and brakes last 3 to 4 years.



Dump body at left has 1-in. manganese steel liners. Center truck lining is 1-in. abrasive resisting steel plate with 3 pct Mn. Truck at right has 1¼-in. cast manganese plates.

Shovel Operation

Four shovels, 2 Bucyrus-Erie electrics with 4 and 5 cu yd dippers and 2 Bucyrus-Erie Diesels with 2½ cu yd dippers moved on the average 13,930 tons per day working one shift, which represents 125 tons per hr per cu yd of dipper capacity.

Safety is stressed throughout the entire mine and particularly in the electric shovel operation. Each shovel circuit has a skid mounted safety breaker. Shovel power passes through the breaker and the shielded ground wires of the shovel cable connect through a relay in the safety breaker box. A resistance to ground of as low as 15 to 20 amp actuates the relay and opens the breaker switch, instantly cutting all power to the shovel. The breakers have justified their use on several occasions. An overhead ground wire is carried as a fourth wire throughout the pit power distribution system. This in turn is grounded at three points in the system. A connection from the ground wire is carried to each of the power connection points together with the power wires. At all connection points the power circuits pass through fused breakers and the ground wire is lugged for ease in connecting the power cable leads. The overhead ground wire as mounted on top of the power poles serves as a lightning arrestor.

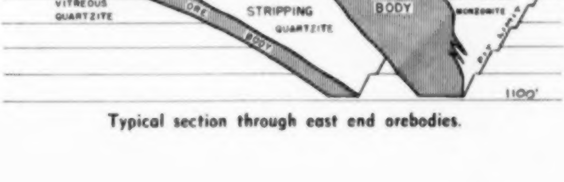
The power distribution system serving the entire operation has an additional safety factor. The distribution system is divided into six separated sections by general areas served, such as houses, shops, crushers and pits. Built into each of these systems and located in the switching station are grounding transformers of the latest design. A ground in any section will instantly open a breaker on the potential power to the section and de-energize it. The State Industrial Accident Commission has complimented the operation for the installation of sectionalized ground protection. By sectionalizing the system, in case of failure by grounding, only a small portion of the operation is affected.

Trucking

A fleet of 20 trucks working on a single shift basis moves 13,900 tons per day. Ten of the trucks are 15 cu yd Euclids; 3 are 15 cu yd Macks and 7 are 10 cu yd Euclids. All are of the two axle end dump type. An an average haul of 1800 ft with 18 trucks working, each truck averages 615 tons per shift. To

In the eastern part of the district, two beds of ore extend east and west for about 2 miles, with an average dip of 45° to the north. The beds are separated by 200 to 250 ft of quartzite and lime silicate rock. Here, the replacement of the dolomitic limestone beds has been complete. Farther west the ore occurs in bands or irregular masses of incomplete replacement within the dolomite.

Principal iron minerals are hematite and magnetite. The former occurs mainly as a secondary mineral after pyrite and magnetite. Isolated small bodies of specular hematite which are of primary origin and small bodies of limonite have been found. The primary mineralization was apparently magnetite and pyrite. The latter was originally distributed widely throughout the ore, however, at most places within 100 to 150 ft of the surface, the pyrite has oxidized. The unoxidized pyrite accounts for the major portion of the sulphur that is present in the ore. Gypsum resulting from the action of acid waters on the limestone, and occurring in small veinlets in cracks and cavities near the surface accounts for the balance of the sulphur.



Typical section through east end orebodies.

The highest grade ore is either a hard, dense, fine grained hematite or a hard, coarsely crystalline magnetite. The lower grade ores are of two types: one, the largest percentage of the total tonnage being a mixture of hematite and magnetite containing disseminated lime, magnesium silicates; the other consists largely of magnetite in a gangue of serpentine and schist.

Under their Strategic Minerals Program, the U. S. Bureau of Mines in 1942 and 1943 did 6700 ft of trenching, 14,500 ft of diamond drilling and 485 ft of underground exploration. Since that time, there has been completed an additional 1000 ft of trenching, 17,000 ft of diamond drilling and 3000 ft of underground exploring. The combined results of all exploration work were used in completing the current mine plans for the easterly orebodies.

As a tool for the exploration and development work for the balance of the property, an aerial survey has been completed, with pictures and topographic maps on 400 ft to the inch scale, at 25-ft contour intervals.

EAGLE MOUNTAIN MINE

Direct Operating Cost Per Net Ton All Material Twelve Months 1952

Total Material—3,511,000 Tons; 21 Days Worked per Month 13,930 Tons per Day—Single Shift

	Labor*	Repairs	Supplies	Special Items	Total
Drilling and Blasting	.05	.01	.03	(Explosives) .06	.15
Shovel Operation	.01	.02	.01	—	.04
Truck Operation	.03	.02	.01	(Tires) .01	.07
Total	.09	.05	.05	.07	$0.26

Tons Ore	—	1,629,000
Tons Waste	—	1,882,000
Total Tons	—	3,511,000

Average Length of Truck Haul 1800 Ft.

* Labor also includes: direct supervision, and payroll taxes and insurance.

maintain this tonnage rate, pit floors and haul road are maintained in a condition equal to pavement.

Material out of the pit moves either on the level or down grade at 7½ pct, so that engine power in the haulage units becomes secondary to braking capacity. All trucks are equipped with Parkersburg Rig and Reel Co., 15-in. Hydrotarders mounted on the drive shaft between the two universal joints. A separate water system, including a 115-gal steam-off tank, is mounted parallel to the truck frame. Power for the system pressure pump is taken off the drive shaft, and the control mounted on the dash is connected by linkage to the three-way valve. Truck speeds can be held to a safe 9 to 15 mph on grades. Use of regular truck brakes is held to minimum and relines are required only after 3 to 4 years of service.

Experiments have been made with various types of liners to protect the truck bodies. The usual rails and angles have proved to be of short life and continually in need of maintenance.

In May 1950, a new 10-cu yd body was purchased in which 1¼-in. cast manganese plates were installed in sections. The body is still in daily service and can be seen on the truck to the right in the picture. No repairs or maintenance have been required to date. The manganese work hardened quickly and wear on the liner plates has been minimum.

With this experience, in October 1951, when new 15-cu yd trucks were put in service, 1-in. cast manganese liners in small sections were installed. This body is on the truck to the left in the picture. The thinner plate has given good service, but the smaller plates have tended to bow. Installation was slower as many more bolts were required. Note that the plates in each of these two bodies were designed so that, as plates wore, they could be changed around. Wear has not necessitated this.

One more type of liner was tried. In May 1952, five trucks were lined with 1-in. abrasive resisting steel plate having a 3 pct manganese content. The truck in the center of the picture shows this type. Installation is fast and maintenance has been nil. The A-R plate is wearing well.

The conclusion recently reached by the mine operation is that the A-R plate will make a most satisfactory and economical liner.

Cost Data

Operators are interested in production cost figures, presented herewith is a re-cap of a 12 month period, showing direct operating costs covering the three major operations of the mine. In quoting these figures, all overhead, property taxes, interest, depreciation and depletion costs have been excluded, as these vary by locations and individual companies' accounting methods. Basic to all operations are direct cost for labor, maintenance repairs, and operating supplies; only these have been included.

Railroad Operation

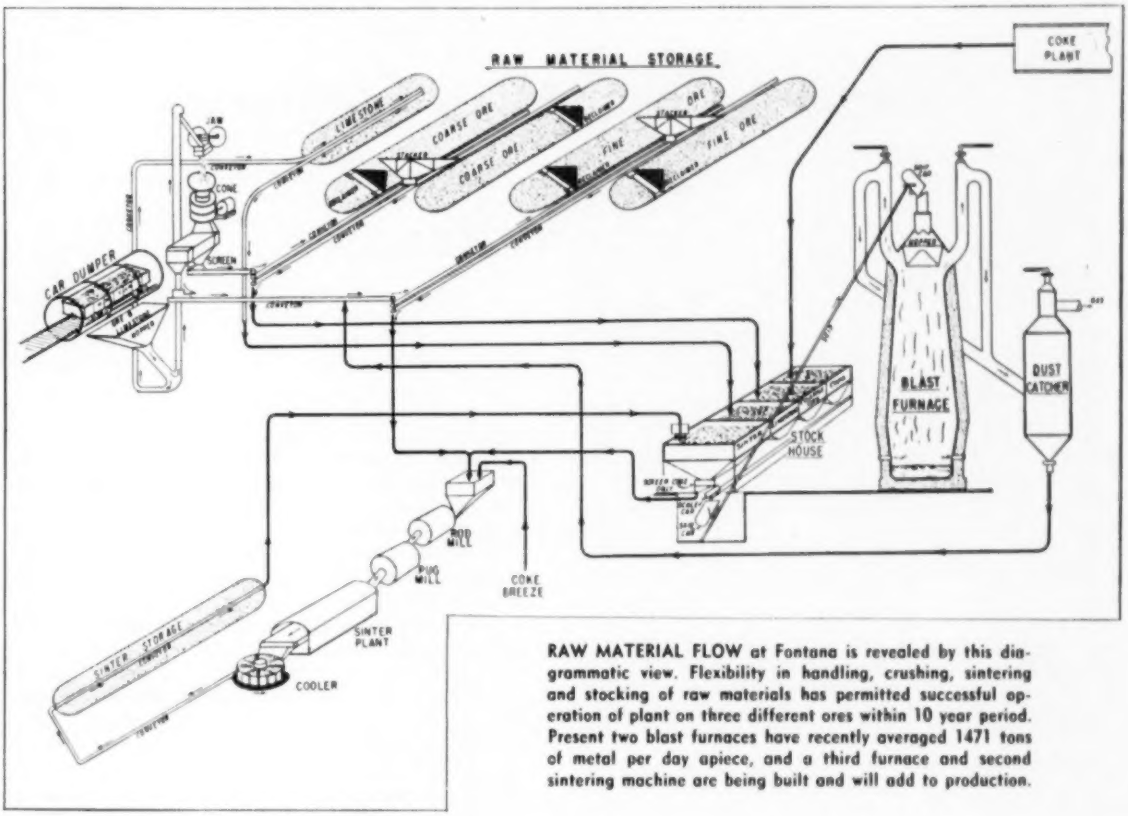
Eagle Mountain mine is located 51 miles northeast from the Southern Pacific Railroad's "Sunset" mainline. In 1946 and 1947 Kaiser Steel had constructed, under contract, a standard gage railroad to connect the mine with the Southern Pacific. The junction named Ferrum lies near the Salton Sea.

The railroad is a part of the overall mine operation. Four 1600-hp, 150 ton, Baldwin Diesel-Electric locomotives serve as power units for hauling 90 to 110 cars per day. Railroad cars used in the ore service are the steel gondola type, of 62.5 tons capacity, and are supplied by the Southern Pacific. Daily ore hauls will vary from 5600 to 6500 tons. Two turns per day, each requiring 7 to 8 hr, handle the required daily tonnages.

Ruling grade against the loads is 1 pct compensated and the ruling grade against the empties is 2.15 pct compensated. Locomotives are equipped for multiple-unit operation and with electro-dynamic braking for the excessive grades as mentioned. Total distance from the mine to Kaiser Steel at Fontana is only 163 miles.

Railroad to Ferrum and junction with SP mainline is part of overall mine operation. Four 1600-hp Baldwin Diesel-Electric locomotives supply power.

Where Eagle Mountain Ore Goes:



RAW MATERIAL FLOW at Fontana is revealed by this diagrammatic view. Flexibility in handling, crushing, sintering and stocking of raw materials has permitted successful operation of plant on three different ores within 10 year period. Present two blast furnaces have recently averaged 1471 tons of metal per day apiece, and a third furnace and second sintering machine are being built and will add to production.

Prior to 1949, the Fontana blast furnaces used 44 to 49 pct Fe ore from Cedar City, Utah, and high-sulphur Vulcan (California) ore. Vulcan ore was sintered to reduce its sulphur content by 95 pct.

First large scale test runs of a new Eagle Mountain, Calif. ore deposit were made in 1947. Analysis of ore in place indicated wide variations in physical and chemical properties. Average analysis of proven ore was 51.2 pct Fe, 0.4 pct sulphur and less than 0.1 pct phosphorous.

Shipments of Eagle Mountain ore to the Fontana plant began in the spring of 1949. At Eagle Mountain ore is mined at several locations to smooth out variations in analysis. It is crushed to 8-in. size, stockpiled and later reclaimed into cars for shipment to the plant.

Incoming lump ore is crushed at Fontana in a jaw and a cone crusher, and screened to a size of $-1\times\frac{3}{8}$ in. for direct addition to the furnace. Ore is stocked and reclaimed by a bedding system to equalize variations in ore analyses and physical size, and to insure feed of pre-analyzed ore to the furnace bins.

Ample flexibility was provided in the basic design of the Fontana plant in all elements of crushing, screening, stockpiling, sintering and conveying of raw materials. This flexibility is responsible for the successful operation of the plant which, in 10 years, has used three widely differing types and qualities of ore.

The $-1\times\frac{3}{8}$ in. coarse ore and $-\frac{3}{8}$ in. fine ore are being stocked separately. Coarse ore is reclaimed directly from the bedding system for charging to the furnace. Fine flue dust is combined with fine ore as sinter plant feed.

Present sinter plant consists of a 72 in. x 102 ft 2 in. Dwight Lloyd machine with capacity to sinter approximately 36 pct of the ore for the operation of two furnaces. A second sintering machine is being installed so that approximately 40 to 45 pct of the ore for the furnaces will be sintered when the third furnace is placed in operation late this year.

Coke breeze, added to the sinter is ground in rod mills to $-\frac{1}{8}$ in. size. Coke, flue dust and fine ore are mixed and conditioned in a pugmill prior to introduction to the sinter bed. Sinter discharge is cooled in a novel atmospheric type cooler developed and patented by Fred Greyson of Kaiser Engineers.

It has been demonstrated at Fontana that increased sinter content improves furnace practice by reduction in fines and sulphur content of the charge. Furnace practice improved through reduction in average ore size, despite reduction in sinter. As was previously mentioned, sinter capacity at Fontana is being doubled to permit use of 40 to 45 pct sinter when the third furnace is blown in, rather than 36 pct.

In connection with ore use at Fontana, uniformity of furnace burden materials has resulted from an improved stocking and bedding system. Controlled sizing of all materials charged to the blast furnace has produced smooth furnace operation and high production rates. Sintering of ore to reduce fines and sulphur content of burden has also improved furnace practice. Flexibility in plant layout has permitted development of successful practice with widely differing types of ore.

Fenimore Plans Mine Operation In Northern Reaches

CANADA, which appears to be growing into one big mining camp, may soon be the background for another impressively large iron ore development. And again it will be Fenimore Iron Mines who will be the motivating force. Dr. J. A. Retty, Fenimore president, who was one of the important figures in the development of Labrador iron deposits, predicts a great future for property on the west coast of Ungava Bay in deep northern area of New Quebec. Fenimore properties consist of a 200 sq mile concession in addition to several hundred claims over about 112 miles along the Labrador trough, mainly in the Ungava Bay region.

Iron formations of the Labrador trough on the Fenimore properties reportedly extend almost without interruption for 52 miles from a point 16 miles north of Leaf Lake southward to Dragon Lake. A deep water channel suitable for ocean shipping connects Leaf Lake with Ungava Bay. Variations in thickness, width, and composition (iron oxides, and carbonate with silica), occur throughout the iron formation. However, the formation usually consists of a top member preponderantly siderite with chert, a jaspery magnetite as the middle member, and specularite quartzitic hematite as the lower member.

A continuous outcrop extending almost five miles exists in the Dragon-Irony-Finger Lakes area. Total thickness above ground is 100 ft and exposed width is about 1000 ft. Mr. Retty opines that:

"It is obvious that hundreds of millions of tons are readily accessible for open pit mining with probable extension occurring to the east under overlying beds of shale and quartzite."

Battelle Memorial Institute, Dorr Co., and American Cyanamid Co., have been making processing tests on samples of ore from the Ungava Bay properties. Results at Battelle indicate that one type of ore consisting of specular hematite and magnetite can be concentrated via magnetic roasting and grinding to -100 mesh for a product assaying over 60 pct iron.

Assays ranging from 34.6 to 41.2 pct iron and 1.76 to 3.11 pct manganese were obtained from an area 5 to 10 miles south of Leaf Lake when samplings were taken from the main band of iron formation for thickness of 29 to 59 ft. Slightly lower assays were obtained from Irony and Finger Lakes areas. Five channel samples taken at South Leaf Bay, ranging in thickness from 18 to 80 ft assayed from 32.3 to 48.7 pct iron. On the original concession area, some 80 miles south of Leaf Lake, large deposits of siderite with interbedded chert occur along a 22 mile long iron formation. Gossan Hill is located in this area.

According to a news story in the *Northern Miner*, geological mapping, outcrop samples, exposed vertical sections, and results of drilling now in progress, led Mr. Retty to make estimates of probable tonnages:

Div.	District	Tonnage (in millions)
1.	Gossan Hill	200
2.	Dragon-Irony-Finger-South Leaf Lake	333
3.	North Leaf-Mannic Lake	33

Fenimore plans an annual production of about 5 million tons. It will take some $68 million to reach this goal. Officials of the company are satisfied that it is economically possible to concentrate deposits already known. Despite the remote location of the deposits, the transportation problem can be defeated by dependence on deep water for profitable operation. General Engineering Co., makers of a comprehensive survey of production problems, have offered evidence to support the conviction. H. A. Strain, Fenimore board chairman, says that a superior iron product can be delivered to European, English, and Eastern U. S. ports with a $3 to $4 per ton profit margin before taxes.

What will per ton operating costs amount to? Transportation, taxes and amortization of investment over a 30 year period, and other items play a part in figuring operating cost per ton. Main item of course is $1.57 per ton of concentrate for open pit mining, and $3.39 for beneficiation. With amortization and office expense, total cost has been placed at $6.93 per ton of concentrate FOB Leaf Bay. Ocean freight and taxes would be additional. Costs may be reduced providing the estimate of two tons of ore for one ton of concentrate should prove high.

The estimated $68 million needed for the project includes $4 million for mining equipment, $20 million for a beneficiation plant, $6.5 million for power plant facilities, $8.5 million for plant to ship transportation, $10 million for docking installations, and $4 million for a town, with housing facilities for about 850 employees.

An Interview With Louis Buchman

LOUIS Buchman walks down the hall of Kennecott's Chrysler Building offices as if he belonged there, but it wasn't his setting of choice. The West has become his home, that and the scene of operations is there.

When he was a child his family came to the United States from Latvia and settled in Michigan's Upper Peninsula where he went to school and on to Michigan College of Mines. Graduating with B.S. and E.M. degrees, he headed west in 1907 to the mining camp of Ophir, in the state where he spent the bulk of his career — Utah.

During the next few years he gained varied experience as engineer, surveyor, assayer, and cyanide plant superintendent, at mines in Nevada, Utah, Arizona and Oregon. In 1914 he went to work for Utah Copper Co., the company he was to stay with for nearly 39 years. He became assistant mine superintendent in 1923, mine superintendent in 1930. From 1938 until 1946 he was general superintendent of mines; from 1946 to 1949 general superintendent of all operations for the Utah Copper Division. On January 1, 1949 he became general manager, Utah Copper Division, and October of that year he was named general manager of Kennecott's Western Mining Division. It might also be mentioned that in 1949 Mr. Buchman received an honorary degree of Doctor of Engineering from Michigan College of Mining. In 1952 Mr. Buchman was elected vice president and director of Kennecott, continuing to supervise all western operations until his retirement.

When asked what he felt were the most significant changes over the years, he spoke of the tremendous strides made in mechanization, electrification and standardization. From steam powered railroad type shovels to full-revolving electric units on "Cats". In haulage service, from small steam locomotive to more powerful electrics. Dump cars as small as 6 yd capacity were in waste service, now 40-yd air operated, automatic dump cars are standard equipment.

There have been a lot of changes outside the pit in his four decades at Utah Copper. A precipitation plant for the treatment and recovery of copper from leach solutions from waste dumps; transition from gravity to flotation concentration enabled each of the two concentrators to mill up to 50,000 tons of ore daily with a copper recovery in excess of 90 pct; development and installation of molybdenum recovery units when the industrial use and market demand for this material warranted such expenditures; the new 100,000 kw power plant supplying all company power needs except for emergencies, and most recently, the electrolytic copper refinery which is now in operation.

Along with the big equipment changes there came the use of tractors, electric tie tampers, tractors mounted drill rigs, mobility of equipment. Bigger, faster, more efficient machines.

Asked about the people who worked with him, he said: "I'd rather not, you mention one, and you should mention everyone". He paused, "I do want to say something about Jackling". I have the deepest respect for his foresight, a strong loyalty to him. He was the drive that made things go. He aroused loyalty, you worked like hell and you knew he would too, and he was loyal to his men".

Excluding employees at the copper refinery which was placed in operation during the Fall of 1950, there are 4919 men and women on the Utah Copper Division payroll. Presently employed are 883 employees who have had 20 years continuous service and 434 who have been on the payroll for 30 years or more. "This is outstanding evidence of what I term reciprocal loyalty between the employees and the Company."

Then he spoke of Jackling's axiom, that if you could show a saving of 1¢ a ton handling ore or waste he would back a capital expenditure of one million dollars. "You know one cent a ton doesn't sound like much, but on 70 million tons of ore and overburden mined and transported yearly there is a saving of about $700,000.00 yearly."

"The company kept moving to larger, faster equipment. When better equipment became available and saving could be effected, it had the vision to place these new machines into operation. Output per man shift increased three-fold during these years as the result of such a far-sighted policy. There hasn't been too much change in fundamental methods."

But when pressed for things more important personally, he turned to safety.

"Our safety record over the years has been a most instructive and gratifying experience." From his days as a safety engineer, Buchman has carried along not only first hand knowledge of safety problems, but a strong response and pride in safe working conditions. He spoke of the wisdom in better housing, development of physical and social welfare programs. Those aren't his words. He speaks of houses, swimming pools, playgrounds; he sees the concrete accomplishment of better living for people he knows and worked with.

RUM JUNGLE

Rum Jungle — deep in the unlovely Australian bush — is the scene of one of the world's most promising uranium finds.

Three key men in the development of Rum Jungle are from left to right: Hector Ward, resident geologist in the field; Jack White, Northern Territory bush prospector who discovered Rum Jungle; and resident geophysicist Don Dyson who made another important discovery not far from White's find. They examine a sample with a Geiger-Muller counter.

Resident geophysicist Don Dyson and Eric Cornell, field assistant, survey an area close to the main deposit to determine radioactivity. The work in coarse grass and sparse bushland which typifies the country within 100 mile radius of Darwin. Rum Jungle is not noted on most maps currently in use. Some copper finds were previously made in the region.

RUM Jungle isn't big enough to be on most maps currently in use, but sometime in the near future it may be of tremendous tactical importance in the battle for position in the race for atomic supremacy. It lies about 55 miles south of Darwin, Australia, deep in bush country, almost primitive. Rum Jungle is in the summer rainfall area—with a monsoonal wet season that lasts from November to April. Coarse grass and sparse open bushland presents an unpromising vista in a warm humid setting.

Darwin itself may soon take on added significance as the portal through which uranium will flow to the world outside. During the tough years following the almost prostrating Japanese blows in the South Pacific, the city served as the jumping off point for the island hopping campaign which led to victory.

One day, not too long ago, bush prospector Jack White read a uranium prospecting handbook issued by the Commonwealth Bureau of Mineral Resources. It jogged his memory. He reexamined old copper workings in the Rum Jungle area. Samples of torbernite and uranium ochres that White sent in for analysis resulted in a search which included geological mapping, airborne scintillometer surveys, ground surveys, geochemical testing and drilling.

That radioactivity extends over a broad region has been learned from airborne scintillometer surveys. It is also known that certain formations are favorable. Mineralization in beds, similar to those of Northern Rhodesia, also shows similarity to metal associations found in that South African area.

Ore is already going abroad from several promising prospects under development. Local refining will be undertaken by the Zinc Corp., Ltd., assigned the task of mining and treating ore from copper-uranium deposits partially developed by the Bureau of Mineral Resources. The Zinc Corp. is also testing a large number of other deposits known to be radioactive, or to contain oxidized copper minerals but where the primary zone has not been examined.

Testing in the primary zone is essential because of a history of laterization and recent tropical weathering. Poor looking outcrops offer the possibility of interesting copper uranium deposits. Scintillometer surveys revealed broad regional activity and it has been learned that certain formations are favorable.

Copper was found in the Rum Jungle area during the latter part of the 19th century. White investigated shallow workings where secondary copper ore was mined at one time. Most of the prospects opened to date have shown copper-uranium min-

Diamond drilling teams such as this one probed hundreds of feet into the Rum Jungle surface in efforts to define the full extent of Australia's most promising uranium deposit.

Geophysicist Dyson and Geologist Ward examine a geological map of the Rum Jungle region for evidence of possible new deposits. Further exploration quickly followed discovery.

eralization. Some autunite deposits, low in copper, also exist. Another promising area is in a bed of conglomerate where radioactivity has been found over a 2½ mile region.

The Rum Jungle deposits lie on the southern side of a dome structure whose core is a granitic complex 10 miles long. Uranium deposits are in pre-Cambrian sediments intruded by quartz veins and basic dikes. Strong regional faulting and folding produced internal folding, marked schistosity and cleavage.

Giant's Reef, extending more than 50 miles to the southwest of Rum Jungle, is the most striking structural feature of the area. Horizontal displacement of over 3 miles along a northeast trend developed a major dragfold on the northern side of the reef. There are major faults in the dragfold and, more recently, there has been cross faulting.

Hydrothermal mineralization is associated with carbonaceous slates and graphitic schists. Uranium is closely associated with copper deposition in one group of prospects, but in a second group copper is rare. Near the surface the uranium ochres occur with secondary copper minerals, primary sulphides and uraninite appear at shallow depth. Deposition is probably selective replacement of bedding and cleavage in the contorted graphitic schist.

The Crater prospect represents a third type of deposit where low-grade radioactivity is found in a conglomerate bed. The conglomerate is near the junction of a major fault of the Giant's Reef system with the granitic complex. Radioactivity may be due to detrital minerals such as zircon and monazite, but radiation adsorption tests suggest that uranium may be present. Occurrence of this conglomerate where hydrothermal deposits are known lends hope that this radioactive mineralization may have hydrothermal origin.

Structural control of the uranium mineralization may be related to an axial shear plane developed in the dragfold. Main prospects found so far lie along a northeasterly line closely following this axial shear plane. There is some localization of mineralization near intersections of cross faults with the shear zone. Studies of mineralization indicate a close association of chalcopyrite and uraninite. However, though copper mineralization is largely restricted to the slate formation, uranium persists northeastward into lower beds.

There is a good chance that other parallel shears of the Giant's Reef system and other carbonaceous beds are mineralized. Exploration may uncover ore not indicated by surface radiometric surveys.

Tests on crushed uranium ore for yield were made on the spot. Dick Mulvaney of Melbourne, field assistant, is one of the several young mineral men employed at the project by the Australian Government. Current plans call for construction of processing equipment.

During 1952 uranium ore from Rum Jungle was shipped abroad in drums for treatment. Necessary plant and equipment to produce uranium oxide is planned for Australia in the near future.

Where to look for ore—

This is one answer to the question—Why are certain regions of the earth more mineralized than others? Ore is still "where you find it," but geologists constantly strive for better guides to where to search most efficiently.

by Chung Yu Wang

STUDY of two recent papers and a recent book leads one to raise anew the question—Why are certain regions of the earth more mineralized than others?

Mr. Reinhardt[1] rightly emphasizes "the relation of mountain building, or orogeny, with the location of undiscovered ore sources" and points out that "junctioning and intersecting orogens (mountain ranges) create favorable areas for mineralization" and that "curving orogens are also favorable areas." With regard to the "*Abyssal Theory of Ore Genesis*," Mr. White[2] strikes the right note when he says that "the ores of the heavy metals for the most part were depressed to abyssal depths before a solid crust was formed, and were later carried up and deposited in the crust when it was fractured by crustal movements down to the ore reservoir" and that "the preponderance of evidence favors a relationship with magmas at abyssal depth rather than with those confined to a magma chamber." According to the metallurgical hypothesis as to the origin of ore deposits, Dr. Brown[3] stresses the urgency of "suitable structures, especially of the kind to reach deep down within the earth's crust" and says that "the ore horizon is deep, at least as deep as the base of the granitic layer (25 to 35 km.) and very likely deeper still, at the top of the peridotite layer (perhaps 60 km. or 37 miles in depth.)"

All the above would bring up two pertinent questions, (1) why some of the most prominent orogens of the earth are barren of ore deposits and (2) how the metallic ores were brought up from abyssal depths down within the earth's crust.

Looming up among the play of forces in the dynamics of mountain-building are the vertical or radial force and the horizontal or tangential force. Both are orogenic forces, capable of mountain making. The writer maintains that the vertical force is more deep-seated, capable of producing what R. T. Chamberlin has aptly termed the "thick-shelled type" of mountain while the horizontal force is more superficial, capable of producing the "thin-shelled type." Quoting from R. T. Chamberlin: "The thick-shelled mountains have been characterized by open, gentle folding; moderate crustal shortening affecting a deeper zone; strong uplifting, and the extravasation of much lava. Vertical diastrophism seems to dominate over horizontal. Normal faulting is an importaint accompaniment occurring either incidentally as a part of the uplifting process or as a result of subsequent relaxational movements of the raised plateau-like area. . . . In those thin-shelled ranges in which overthrust faulting has been a dominant feature, instrusions formed in this way should not be conspicuous in the marginal portions where the phenomena of overthrusting are best displayed and the shell was thinnest, but rather in the heart of the deformed belt, where the shell involved in the diastrophism went somewhat deeper and lifting was relatively more important".

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These ideas of Chamberlin are pregnant with meaning when taken into consideration with ore deposition. We learn that the metallogenic minerals are stored way deep down in the barysphere. To tap, so to say, this storehouse of ore minerals, there must be application of a force that is far-reaching and profound. It is this vertical or radial force, as conditioned by isostatic adjustment, that causes the up-welling or surgence, to use a term coined by Spurr, of the magma in depth, bringing with it whatever ore minerals happened to exist at the time, along the lines of weakness of the crust, which are located principally between the margins of the continental plateau and the fore-deep or trough of the oceanic basin.

Conversely, the horizontal or tangential force that causes the development of thin-shelled mountains, is not profound enough to reach into the deep region of the earth, and, hence, in mountain chains thus originated, no important ore-deposits of igneous origin are expected to be found. Any discussion of the origin of ore deposits is thus involved in that of mountain formation. Both problems are one and same. If one is understood, the other becomes clear; for both are due to the same fundamental causes.

It is evident now that from the standpoint of ore-deposition we can group the principal mountain chains of the world into two main classes: The coastal Cordilleras (examples, the Sierra Nevada, the Cascades, the Andes, the Dividing Ranges of Australia) and the Arcuate Mountain Ranges (example, the mountain rañges of Asia). Generally the coastal Cordilleras are located on the margin of the continental platform, the descent from which into the oceanic deeps, is usually steep and abrupt. Here along these margins, are the natural locii of the zones of special instability. Of course, there are other mountain systems whose structures may be either of the "thick-shelled" or "thin-shelled" type.

From gravity measurements, and from specific gravity determinations of rocks it is known that the

rising positive coastal chains are composed of lighter rocks while the sinking negative deeps, the rocks of higher specific gravity. Thus can be drawn the only inference that to maintain isostatic adjustment, rock flowed from under the ocean into the column under the mountain areas with great telluric pressure. This great pressure urged the rock magmas vertically upward bringing with them the metallogenic minerals from the reservoir of the abyssal deeps, to form intrusions.

Along regions of the earth with such conditions are located the most famous metalliferous mines of the world.

What connection is there, if any, between the so-called Arcuate Mountains and ore-deposits? Here we have a different story. The horizontal or tangential forces that produced these pronounced mountain chains must have been very superficial, capable only of folding and overthrusting, but not profound enough to reach down to the storehouse of the metallogenic minerals buried in the barysphere. Hence ore-deposits in such regions are sparce and scarce.

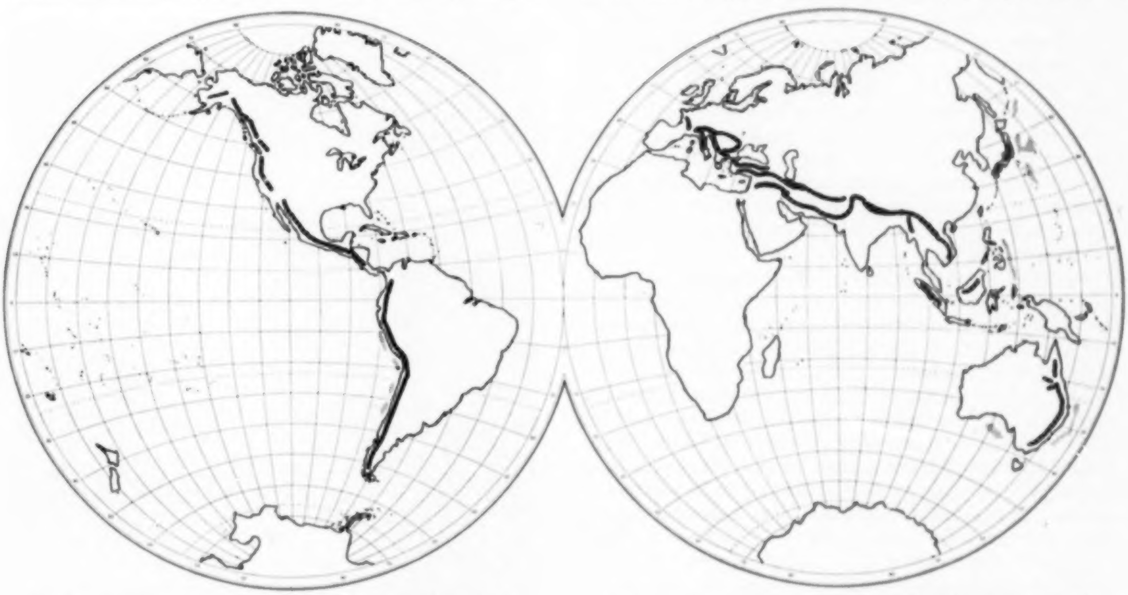
Lines of weakness of the earth's crust naturally occur in regions of folding, and fracturing, in which any future dislocations are only serviceable as indicating whether the forces have been radial or tangential. In these unstable regions of folding, it might be said that there had occurred potential faults or virtual dislocations during the period of mountain-building, waiting to be rent asunder by the increasing telluric force of the magma intruding from below. Thus dykes or veins are concomitant with intrusions and do not necessarily fill pre-existing faults or lines of dislocation, although lean veins and dykes oftentimes fill post-mineral faults.

In a general way it may be said the long coastal mountain chains of the western part of the two Americas owe their origin to radial or vertical forces while the Syntactic mountain chains, beginning with the Pyrenees, passing through the Alps and the Caucasus and continuing to the Kuenlun and Tsinling around the north of Tibet and to the Himalayas around the south of Tibet, are chains of the thin-shelled type, that is they owe their origin to tangential or horizontal force. The richness of various kinds of ore-deposits found in the former can be contrasted at once with the paucity of such in the latter.

So far some fundamental conceptions concerning the relationship between the tectonic features of the earth and ore-deposits have been summarized. Let us now see their application.

The Sierra Nevada. The straight and abrupt east face of this chain indicates the presence of a great fault. The whole chain has been persistently pushed upward by a vertical force acting from below. Therefore, it belongs to the thick-shelled type with its accompanied ore-deposits.

The Andes of South America. This Cordillera has been uplifted by profound faulting. In Argentina, according to Miller and Singewald, "The mineralization of the northern half of the Andes appears to have been wide-spread, more intense, and more diversified than that of the southern half." The reason for this may possibly be that the northern half is fringed by the Richards Deep. It may be discerned here, as well as elsewhere, that the bordering deep of a coastal cordillera has a far-reaching significance in the enrichment of the ore deposits of a region and indicates that, with increasing depth the crustal weakness becomes greater and the vertical force that urges the ore and rock magmas upward, becomes more profound and deep-seated. The same condition is observable in Chile. Here most of the mines are situated from north of Valparaiso to Taca in a stretch of land just bordered by the Richards Deep. The mineral production of Peru has been rapidly increasing as it should be, for she is as favorably situated as Chile, being bordered



World map illustrates some of the principal mountain chains the text classifies as *arcuate*, or *coastal Cordillera*. In the Western Hemisphere, at left, the coastal Cordillera is exemplified by the chain running from Alaska through the Cascades, the Sierra Nevada, and finally the Andes of South America. The Dividing Ranges of Australia are also classified as coastal Cordillera. Prominent in the Eastern Hemisphere is the series of arcuate ranges extending almost continuously from Europe through the Himalayas in Asia. Some of the major deeps (greater than 20,000 ft) of the Pacific Ocean are shown by shading and the text points out a possible correlation between the mineralized areas of the South American Cordillera and the adjacent ocean deeps. Mineralization in Peru, Chile, and Bolivia seems closely related to the ocean deeps.

by the Milne-Edwards Deep. Compared with Peru, Bolivia or Argentina, Colombia is poorer in mineral wealth. With exception of Paraguay and Uruguay, Ecuador is the poorest of all South American Republics in mineral wealth. It is significant to note that both Colombia and Ecuador are not bordered by any known deeps.

The Himalayas. To quote from Wadia, "Broadly speaking, the origin of the Himalayan chain is to be referred to powerful lateral thrusts acting from the north of Tibetan direction towards the Peninsular India. . . . In the severe compression and stresses to which they have been subjected in the mountain-building processes, some of the folds have been inverted or reversed . . . . the plane of junction is always a reversed-fault, with an apparent throw of many thousand feet . . . . known as the Main-Boundary Fault. This fault is a most constant feature of the structure of the outer Himalayas along their whole length from Punjab to Assam". This is quoted at length because, being the most prominent of mountain chains, it is generally supposed to have been caused by vertical force. In short, the horizontal tangential force has played the most important part, in pushing the formations up to such high prominence. In the term of Chamberlin, it is a "thin-shelled" mountain, in which we would hardly expect to find any rich ore-deposits. Such appears to be the case here and lends proof to the present hypothesis.

Other instances of "thick-shelled" ranges are the Dividing Ranges or Cordillera of Eastern Australia, bordered by the Thompson Deep; the Japanese Mountains, bordered by the Tuscarora. Other instances of "thin-shelled" ranges are: The Alps, The Scandinavian Chain, The Scottish Highlands.

Finally, regions, which have remained as land masses more or less permanently throughout the different geological periods, are inherently less mineralized than labile regions, which have become alternately land and sea. A notable instance of such stable land mass is that of the Chinese coastal region from Shanghai to Canton, which has remained as a land mass ever since Cambrian time. Moreover, the region is not fringed by any oceanic deeps. Instead, the ocean bottom around the China Coast merely forms a continuation of the continental platform. Hence, this coastal region, in spite of the prevalent occurrences of igneous and volcanic rocks, is devoid of any ore deposits worth mentioning.

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Lamphouse Design for Better Lamp Care

Physical design and operating procedures of a lamphouse at the Mather Mine "B" Shaft of Negaunee Mine Co., in Negaunee, Mich., includes all of the basic elements for efficient maintenance and distribution of miners' cap lamps.

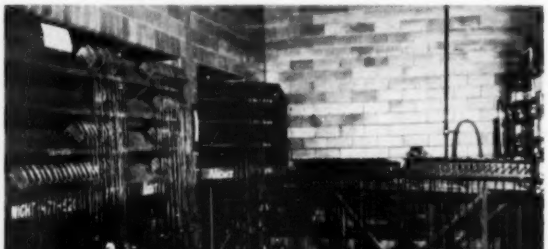
The new system provides: (1) speedy and easy distribution and return of lamps; (2) positive control of distribution, charging and maintenance; (3) maximum utilization of available space, and (4) functional efficiency and responsibility of lamphouse personnel.

An outstanding feature of the operation is use of reversible self-service racks for daily distribution of 544 Edison R-4 electric cap lamps, supplied by Mine Safety Appliances Co. At "B" Shaft, a total of 544 of the R-4 lamps have been placed in service.

The unique racks are built on center pivots in one wall of a corridor between the changehouse and the shaft. On the opposite side of the wall is the lamproom. Lamproom attendants insert charged lamps in slots on one side of the racks and then swing the entire panel around to face the corridor where miners quickly and easily can remove their individual lamps. There are three separate reversible racks, each clearly marked as to shift and clock number groups. Total capacity of the racks is 696 R-4 lamps.

Management says this type of lamp distribution has increased substantially the speed with which miners can pick up or leave their lamps. There is no chance, moreover, of an unrecharged lamp getting back into service.

When the distribution racks are swung around to face the lamproom, the attendant merely removes the lamps from that shift and loads them on a specially designed dolly which then is wheeled to charging racks. Each lamp is carefully inspected before it is placed in the charging rack.



Lamproom side of the new "self-service" lamp distribution system at Mather Mine "B" Shaft. Reversible racks keep lamps separated for each shift, improve distribution and return. At right is a special dolly to carry the lamps between distribution and charging racks.

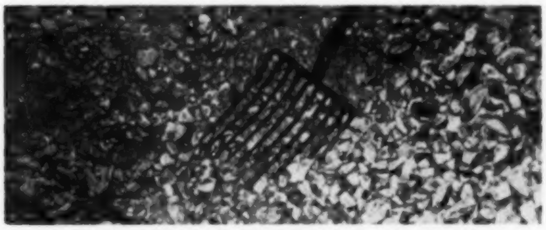
Tennessee Copper Explores Use of Rock Grinding Media

Use of rock grinding media in a mill at Tennessee Copper Corp. was mentioned in the MINING ENGINEERING Annual Review. (February 1953, page 158). Because interest in use of self-grinding media continues high we asked F. M. Lewis, Superintendent of Concentration at Tennessee Copper, to supply more details on this trial, and of plans to expand use of rock media in their mills that grind marble. Here is what he reports.

"Tennessee Copper is extremely interested in ore pebble grinding, and hopes to get its plants on ore grinding media. However, starting two large flotation plants, each with only unit, on ore pebble grinding is quite a problem, because there can be no interruptions or inferior metallurgy. Laboratory work has shown the economics of ore pebble grinding to be very attractive, but so far it has never been possible to obtain good flotation results after grinding ore with ore. A small pilot plant is in operation on this problem right now and it is planned to place a larger mill in this pilot plant.

"In order to get more experience and data on pebble grinding, some work is being done with a mill grinding marble for use in neutralizing the acid in the streams.

"Each of these units has a 5x10-ft mill, previously using 1-in. steel balls for grinding media. One mill is running at full capacity and handling 80 to 100 tons of marble a day. The other mill had been loafing along on 25 to 30 tons a day at a rather low speed. On September 10, 1952 the grinding media in this 5x10 mill was changed from 1-in. steel balls to coarse marble, size −3 +1½ in.



Close-up of —3 in. marble used as grinding media.

"From the very first the results indicated that this change was to be successful. To complete this study a number of additional tests were made to obtain data that would be helpful in converting the other mill to marble grinding media. Results of some of the tests are given in the table below.

"Tests 2 and 3 were equally as good as the base line, Test 1. Test 4 was unsatisfactory because there was no flexibility with this set-up. The mill was fed

This 5x10-ft mill is now running with coarse marble instead of 1-in. steel balls as grinding media.

marble from a jaw crusher that had been set to 3-in. The mill produced overground product, and the classifier had very little to do. However, this could not be corrected, because if the feed rate was increased, the level in the mill rose, and coarse marble spilled out through the discharge trunion.

"Test 5 was not as efficient as tests 2 and 3, because the mill was running too fast. By increasing the speed from 32 to 36 rpm the critical speed was increased from 90 to 101.5 pct of critical.

"Since completing these tests, −3 in. crushing products have been used as the grinding media adding 4 mesh marble as feed. *(Screen analysis of −3 in. marble is 14.8 pct +2 in., 92.2 pct +4 mesh. Marble feed is 99.0 pct −4 mesh, 82.7 pct +48 mesh.)*

"The other mill is being converted to use the crusher product from the marble plant as grinding media. It is planned to lengthen this second mill by bolting another 5x10-ft shell to it, making it 5x20-ft. It is also planned to put in a discharge end with lifters and use it as a low discharge type (the first mill does not have a grate). The mill will be speeded up to 90 pct of critical and calculations indicate it will draw 106 hp, which would be plenty to mill 80 to 120 tons of marble in this particular operation. It will be late in the summer before this second mill is in operation, but the results from it should be most interesting.

"Several points are of interest, one is that 90 pct of critical is certain an efficient speed, in this application. Another is that there has been no accumulation of chips from the media.

"The mill has not been operated long enough to know anything about the liner consumption, but it might be mentioned that the ball and liner consumption was quite low when using steel balls."

Results of Grinding Tests

Test	Grinding Media	*Ratio Feed to Media	Rpm	Hp	Tons Daily	Product +325	Product −800 Mesh	KWH Ton −800 Mesh
1	1 in. Steel Balls	——	18	53	28	8.0	54.5	64.8
2	−3 in. + 1½ Marble	3 to 1	32	53	30	11.0	53.5	61.8
3	−3 in. + 1½ Marble	3 to 1	32	53	45	30.0	36.3	62.9
4	−3 in. Marble from Crusher	0 to 1	32	58	22	4.5	70.0	67.6
5	−3 in. + 1½ Marble	3 to 1	36	61	30	36.0	29.1	136.3

* Feed is the regular fine marble product, practically all 4-mesh, from the Georgia Marble Works.

Aluminum Mine Props Save Labor, Last Longer, Improve Safety In German Coal Mines

by Max Stern

Aluminum props protecting a chain conveyor provide light weight, long life, and yield without abrupt, dangerous failure.

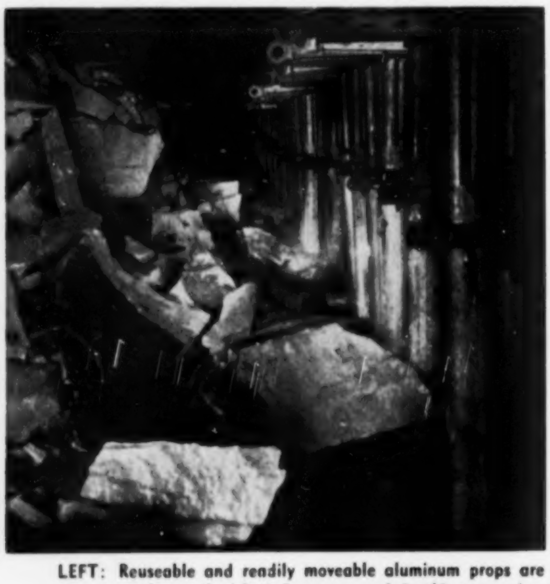
ROOM and pillar coal mining methods employed in the United States keep the roof at original height by leaving untouched pillars of coal in the face area. But, German coal mines of the Ruhr district are exclusively operated on the longwall system. With this method the whole length of the coal face advances and the roof in the face area sinks 10 to 15 pct of seam thickness. Behind the face the roof may drop 50 to 80 pct of seam thickness due to the high rock pressures encountered at average mining depth of 2250 ft. Mining depth is increasing 20 to 30 ft per year.

It is easy to understand the quality and strength of construction materials needed under mining conditions such as these. Mining in Germany, where the roof must be steadily supported requires removable, yielding props. Mining difficulties can be further emphasized by pointing out that mine entries in Germany are almost exclusively driven in rock, while in the U. S., they are usually in coal.

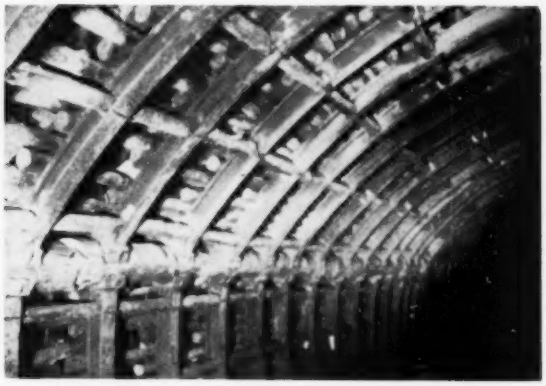
MAX STERN is a consulting engineer, New York City.

Because of great timber shortage, Germany started about 30 years ago to replace wood with steel as the support. Ever increasing rock pressure was also requiring more and more expensive support. At the end of World War II only 33.8 cubic meters of timber were used per 1000 tons of coal produced. Today this has been further reduced to 24 cubic meters per 1000 tons of coal.

The constant underground movement originating from high pressure in deep mining made flexible construction of the supporting material necessary. It was always a great problem under these difficult conditions to build and maintain the many permanent entries which are used for the transportation of the miners and of the coal cars to the hoist. Until 1920 ways were built and supported exclusively by obsolete soft wrought iron rails because of their flexibility. The 3000 to 4000 tons needed every month became less available and after 1920 iron rails were replaced by obsolete steel rails. Steel rails, however, became dangerous and uneconomical because of their inclination to break unexpectedly under high loads. A special new rolled wide flange



LEFT: Reuseable and readily moveable aluminum props are used here with cantelevered aluminum beams. RIGHT: Aluminum props are also used with timber caps, and, in this case, wire net lagging to hold side.



LEFT: Close-up of annealed obsolete steel rails used for support in main entries. Annealing process reduces hardness and brittleness of steel, eliminates unexpected failures. RIGHT: With flexible couplings and cold bends, almost any cross section can be provided as required by formation. Note more conventional shapes in foreground, arch in distance.

beam similar in quality to specification ASTM 105 was introduced by the Steel Mills with an approximate weight of 66 lb per yd. However, the high cost of these beams increased mine operating costs.

In 1925 the writer succeeded in reducing hardness and brittleness of the obsolete steel rails by an annealing process. Treated rails again played a predominant role as supports in the Ruhr Coal Mines, Saxonia and Upper Silesia as well as in Holland and Belgium where similar conditions prevail.

With flexible joints, 180° and even 360° arcs could be cold bent from the annealed old rails, considerably increasing resistance against pressure and eliminating to a great extent the use of timber. More than 400 miles of entry were built with these rails up to the end of 1939 and most of it is still in use.

Longwall mining used yielding steel supports exclusively up to 1948. However, because of the heavy weight of steel props, it was impossible to use them in steep and semi-steep formations. Here, until recently, only timber could be used. After the release of aluminum production in 1948 by the Military Government aluminum props were tested to replace timber in these formations and in longwall mining.

Dr. W. Hoevels, an outstanding German mining engineer, designed and constructed a special yielding aluminum support made with telescoping tubes that was suitable for both steep and horizontal formations. Economic advantages of these supports were: 1—Reduction of weight, eliminating high transportation and labor costs. 2—Longer life than steel props. 3—Yield of the "hard props" continued even with maximum load. The especially flexible removable mine supports reach final load after the prop has yielded ½ to 1 in.

Great saving in labor was possible with the lighter props because they must be constantly removed and set-up again, by hand. With aluminum the weight of the props was reduced to approximately one third and one man is now needed where previously three were required. In addition, wear and tear, and repair have been reduced in comparison with steel. Scrap value is about one third of investment cost.

Aluminum supports are now manufactured in Germany at a rate of 5000 to 10,000 weekly. Some English coal mines have recently switched over to aluminum by ordering 5000 to 10,000 supports a month from Germany.

LEFT: Larger props show more detail of special collar used for adjustment of tension, and show top plates adapted for timber caps. RIGHT: Only one man is needed to handle aluminum mine support, where three were required for steel supports.

Ion Exchange—

Another Tool For Hydrometallurgy

ION exchange is one of hydrometallurgy's new tools, new in application, yet old in principle. Cation exchange between solution and a solid exchanger has been known for more than a century, but ion exchange is still in its infancy for metallurgical use. Still hampered by cost of media, it is faced with much development of actual physical handling.

Growing consumption of the rarer metals and need to treat leaner ores are pushing extractive methods ahead. Public concern with stream pollution, or legal requirements, are forcing a clean-up of waste discharge. Industries are finding it vital to make some recovery from heretofore waste material to help pay costs of discharge treatment.

It is here that ion exchange may provide the answer. Suited to extraction of valuable ions present in minute quantities, it yields them in concentrated form upon regeneration.

Basically the process consists of passing the solution to be treated through a bed or reactor containing the exchanger. When the bed is saturated it is regenerated by a strong base or acid and adsorbed ions are recovered in high concentration.

A cation exchange material will remove cations, leaving anions and neutral molecules, and an anion exchange media will do the reverse. Selectivity between ions of like sign can be partially attained. Initially cations or anions are taken up indiscriminately until a saturation is reached—then preferential adsorption will displace certain groups. A similar method may be applied during regeneration or desorption, certain ions being removed first.

Broadly speaking these reactions are governed by the law of mass action using activities—within the limitation of available absorbable surface. The adsorbing surface may be external, or as in the case of the zeolites and resins largely internal, with a resulting tremendous increase in exchange capacity. Aside from the law of mass action, "rules of thumb" indicate that exchange rate favors either ions of higher valence or higher atomic number.

Since advent of synthetic resins, media costs have been reduced and durability improved. But, the first synthetic resins and the sulphonated coals, like the earlier zeolites, lacked the ability to remove negative ions from solution, i.e. they were only cation exchangers. Most recent step forward offers either cation or anion removal.

Newest development is ion exchange composition in membrane form of large dimensions. These membranes open a new field of electro-chemistry and exchange technique. Functioning as permselective barriers of high conductance, they permit many electrolytic processes to be carried out at high ampere efficiencies. Recovery of acids and bases and concentration of electrolytic solutions are examples of applications for this new unit process.

About 90 pct of resins produced today are used in some form of water purification. Originally only calcium and magnesium ions were removed, but recent *deionization* technique calls for removal of both cations and anions by two step exchange or in a mixed bed. Other fields are growing increasingly important and copper, zinc, silver, chromates, vanadium, and gold are all being recovered.

Present applications of ion exchange range from purification of pharmaceuticals, antibiotics, to separation of the rare earth elements by the AEC, and recovery of vanadium from petroleum. Industrial uses pointing the way for the mining industry are recovery of copper sulphate from cuperamonium rayon manufacture wastes and its return to the circuit in concentrated form; recovery of chromate ions from chromic acid treatment washes; and purification of solutions in closed circuit.

As a tool of hydrometallurgy, ion exchange offers several possibilities aside from selection of specific ions by multiple exchange and closely controlled desorption technique. Concentration of solution and purification by removal of ions of certain sign may prove more important. Exchange can recover ions from very dilute solutions such as discarded wash water, the recovered ions being then stripped from the exchange resin during regeneration and recovered in concentrated form. Important factor is rapid, easy filtering of the granular resin.

Commercial application of the adsorption regeneration cycle is essentially batch in nature. However, by means of alternate cycling through dual circuits, and provision for reversal of flow during stripping continuous treatment may be approached.

Handling the resins is still probably the biggest obstacle to widespread use in metallurgy. Application of present media to ore pulp runs into problems of regeneration and abrasive destruction of costly material. One way around this difficulty lies in cheaper media that do not have to be recycled. An example of this is use of charcoal for gold recovery from cyanide solutions, followed by destruction of the charcoal.

Of particular interest to the miner is another process whereby gold may be recovered from cyanide solutions by exchange. This is under development both here and in England. In this process granular ion exchange resin is mixed with the ore during leaching. Slimes may be present without affecting recovery, since the resin filters readily. The gold cyanide complex is recovered along with metals such as copper, nickel, and zinc. Simple agents such as hydrochloric acid remove nickel, zinc, etc., prior to stripping the gold with an organic reagent containing an acid group. Basic materials are not cheap, initial cost would be high, but resin life is expected to be good, bringing the process within range of economic feasibility.

Most unique application to beneficiation so far is iron ore flotation process patented by Hazen that employs ion exchange to remove adsorbed cations which repel collector from ore particles. A fatty acid collector is used, followed by addition of coarse granular exchange media to adsorb the undesired cations. Sulphonated coal, synthetic aluminosilicate gel and resins are suggested. The exchanger is separated from the pulp prior to flotation by screening or other mechanical means and reused. Principal problem is said to be media abrasion losses.

Uranium Mineralization in the Sunshine Mine, Idaho

by Paul F. Kerr and Raymond F. Robinson

Uranium mineralization occurs in the footwall of the Sunshine vein from the 2900 to the 3700 level. Veinlets of uraninite associated with pyrite and jasper have been so extensively divided and recemented that units more than a few feet in length are seldom observed. The wall rock is St. Regis quartzite of the Belt series. The age of the uraninite, on the basis of isotopic analyses, is 750 ± 50, which agrees with geological data suggesting that phases of the Sunshine mineralization are pre-Cambrian.

THE Sunshine mine in the Coeur d'Alene district, Idaho, is well known for its silver-bearing veins but prior to the summer of 1949 had not been recognized as a possible source of uranium. At that time, during a geiger counter reconnaissance by T. E. Gillingham, R. F. Robinson, and E. E. Thurlow, high radioactivity was noted and radioactive specimens were collected from the footwall of the Sunshine vein.[1] The detection led to the identification of uraninite-bearing veins, since explored jointly by the Atomic Energy Commission and the Sunshine Mining Co.

After the occurrence was noted, the geology of the uranium deposit was studied by the Sunshine staff, and a laboratory examination of the ores was conducted at Columbia University. Several types of laboratory work were undertaken. Differential thermal curves were made of selected siderite samples and results from many more were secured through the work of Mitcham.[2] X-ray diffraction and X-ray fluorescence analyses were employed on uraninite, jasper, and siderite. Chemical analyses were made through the cooperation of the Division of Raw Materials of the Atomic Energy Commission.

General Geological Features

Several silver-bearing veins cut the overturned north limb of the Big Creek anticline as mapped by Shenon and McConnel,[3] while the Osburn fault, a long-recognized regional feature about a mile away, marks the north boundary of the Silver Belt.

The Sunshine vein, Fig. 1, has a south dip more or less parallel to the 60° axial plane of the fold and cuts rocks of the Belt Series, starting with the Wallace formation near the surface, continuing downward through the St. Regis formation, and probably extending into the Revett quartzite which lies below the bottom or 3700-ft level.

The limb of the anticline is locally modified by secondary folds, one being prominently exposed in the uranian area along the Jewell crosscut near the Sunshine vein. Crumpling of the limb resulted from compression which formed the anticline and probably preceded the faults in which the vein deposits accumulated. Evidence of drag along these faults points to reverse movement in the uranium-bearing area and elsewhere. This is true of major faults in the mine workings, and the majority of faults which can be mapped, as pointed out by Robinson.[4]

The St. Regis formation, as measured in the mine, appears to have an initial thickness of some 2000 ft, but the apparent thickness due to thickening during folding is some 3400 ft. Along the Sunshine vein the purple and green rocks characteristic of the Wallace formation in the nearby Military Gulch section[5] (p. 37 of ref. 5) have been completely *bleached* because of introduced sericite. Hydrothermal solutions acting on the wall rock have substituted for the original color a pale greenish cast, although no pronounced mineralogical change has resulted, as Mitcham has observed.[2]

The silver and the uranium depositions appear to belong to distinct epochs resulting from several periods of emplacement. Likewise, multiple periods of deformation account for the faulting. Uraninite is generally associated with silicification, while silver mineralization accompanies carbonate veins. Rarely, uraninite may be found in a matrix of siderite. Ordinarily uraninite formed prior to argentian tetrahedrite. Where clusters of veins form a stockwork, uraninite-jasper veins often favor one trend while tetrahedrite-siderite veins favor another.

During deformation, brecciation of the St. Regis quartzite provided openings between broken rock fragments for precipitation from vein-forming solutions. Fractures due to major breaks were filled during the first stages of vein formation, while later deformation displaced the first veins and provided new channels along which further mineralizing solutions proceeded.

The uraninite veins, as the first formed, have suffered fracturing, displacement, and segmentation. Uranian vein segments uncut by faults and more than a few feet in length are rare or nonexistent. Siderite veins are more massive and often extend without a break for tens and even hundreds of feet. In general they show much less segmentation. While the siderite is usually later, there is an overlap in the periods of deposition, some earlier siderite veins being extensively segmented in much the same way uraninite veins have been broken.

Vein silica is more extensively distributed than the uranium and iron mineralization it carries. Along the vein course concentrations of uraninite frequently fade away and barren white quartz continues, the transition often occurring within a few feet along strike or down dip. An example appears on the 3700-ft level where a uraninite vein, see Fig. 2a,

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The Transactions papers appearing in Mining Engineering during 1953 will subsequently appear in AIME Transactions Vol. 196, and may be permanently referenced to that volume.

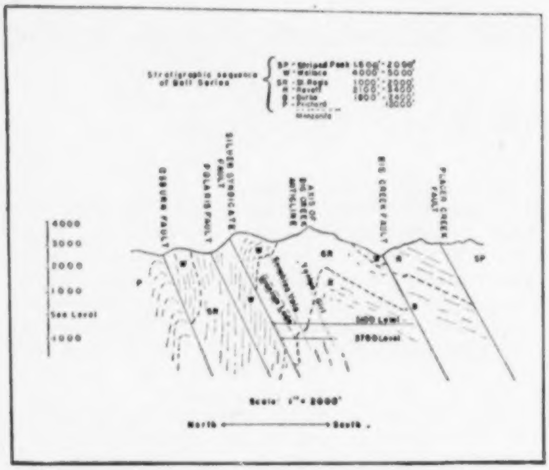


Fig. 1—General structure of the Sunshine mine, shown here in section.

changes within 20 ft to a barren ribbon quartz vein, see Fig. 2b.

Deformation

Uraninite veinlets form clusters near the axis of an anticlinal fold on the north flank of the main anticline, Fig. 3. On the 3100 level west, the crest of the fold has a westward pitch of 15° to 20°, while 200 ft above, the same axis has a westerly pitch of 25°. Below, on the 3700 level, a single uranium vein lies a short distance north of the axis. Here the flank of the fold is slightly overturned to the north. Veins are crumpled in places with post-vein deformation, Figs. 2a and 2b, and are frequently cut by low angle cross faults, or *flat faults*.

The relationship of two silver veins, the Sunshine vein and the 06 vein, to the uranium-bearing zone, is shown in Fig. 3. The strongest uranium mineralization occurs near the west end of the drift but it is noticeably discontinuous, Fig. 4. Veins exposed in drifts and crosscuts may be missing in drill holes a short distance away along the vein strike, while occurrences in drill holes may not continue into nearby workings. On the other hand, the Sunshine and the 06 veins which cut across the uranium zone are continuous throughout the length of the drift.

Low Angle Faults

Flat faults cut the uranium veins and also limit deposition. The fault planes are often irregular, many being folded. Well shown in a stope, 16W, a prominent zone of uraninite stringers follows fracture cleavage westward until cut by a fault plane inclined at less than 10° to 25°. Earlier uraninite vein strands are terminated by this fault, but some later uraninite veinlets follow the fault plane itself.

Flat faults may follow the bedding planes of the St. Regis formation where the strata are inclined at less than 25°S, or they may cut the stratification at a small angle. In the mine area slippage along bedding planes is noticeable, particularly near the local folds. The displacement of uraninite veinlets by a flat fault may be limited to a few feet and in places reduced to fracturing without displacement.

Fig. 5 illustrates a flat fault. Both gouge and quartz introduced along the fractures are impregnated with radioactive particles. Pyrite and arsenopyrite occur in the shear zones. Quartz is also present and changed in places to jasper. The quartzite both above and below the fault is red and radioactive, although more deeply colored and mineralized below. Early siderite-pyrite veins show drag and are truncated by the fault. Arsenopyrite and pyrite of the fault zone are later than the early pyrite of the steep veins. The steep veins taper away from the fault and may have derived their filling from the fault channel at an earlier stage. Thus the flat fault represents more than one generation both of movement and mineralization.

A group of flat faults is illustrated in Fig. 6. These are filled with gouge, curved, and split. Both the St. Regis quartzite and earlier groups of siderite veins are displaced. Ordinarily these faults merely cut veins, but later white quartz at the bottom of the section cuts both early veins and gouge.

Fig. 7 shows a flat fault cutting a system of veins. Movement has occurred along an irregular surface, the two walls being separated by gouge of varying thickness. The patterns of the two walls fail to match, indicating substantial displacement.


Fig. 2a—Uraninite vein, 3700 level. Photograph taken near the Jewell crosscut, looking southeast, shows a surface freshly exposed after blasting. Uranium-bearing zone is outlined with white chalk.


Fig. 2b—Ribbon vein, 3700 level, terminating uranium mineralization. A photograph of a later state in the development of the uraninite vein, showing barren quartz stringers in a crenulated pattern. The boundaries of the zone are indicated by chalk.

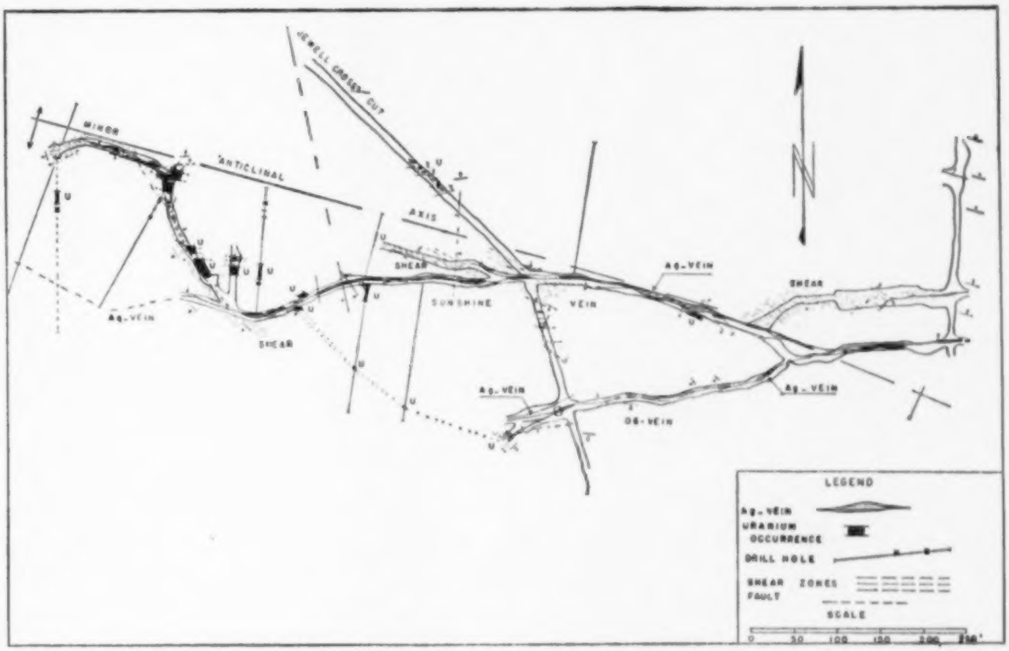


Fig. 3—Uranium and silver veins, 3100 level. The uranium zone intersects with the silver-bearing Sunshine and 06 veins in the vicinity of a minor anticlinal axis.

Above the fault a low grade silver-siderite vein and a light red jasper vein occur a few feet apart. The low grade silver-siderite vein has been cut by the fault, while later white quartz merges with and follows the fault line. About 10 ft below the fault a stringer of red jasper and pyrite merges into arsenopyrite schist. The sequence seems to have been: 1—arsenopyrite vein wall impregnation; 2—pyrite and jasper veins, uranium-bearing; 3—silver-siderite veins; 4—flat cross faulting; 5—white quartz cross veins.

Evidently near the flat faults the flow of solutions carrying uranium continued for a considerable time, Fig. 7. Flat faults are mineralized, Fig. 5, with the possibility that mineralization and movement were partly concurrent.

Shear Zones

Fracture cleavage in the quartzite of the Silver Belt has been described by Shenon and McConnel.[9] Along the 3100 level the angle with the bedding is normally 30° to 45° and shear zones appear to be more highly developed on the flanks of minor folds. The shear zones have provided openings along which both silicification and uranium mineralization have taken place.

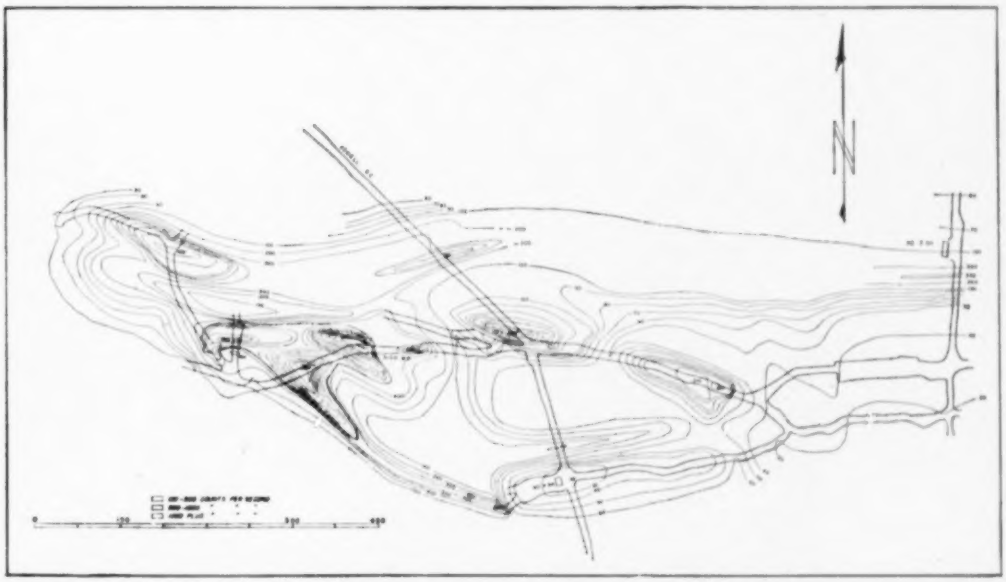


Fig. 4—Radioactivity along 3100 level. The diagram is based upon observations along drifts and crosscuts, and also takes into consideration comparative radiometric data from drill holes.

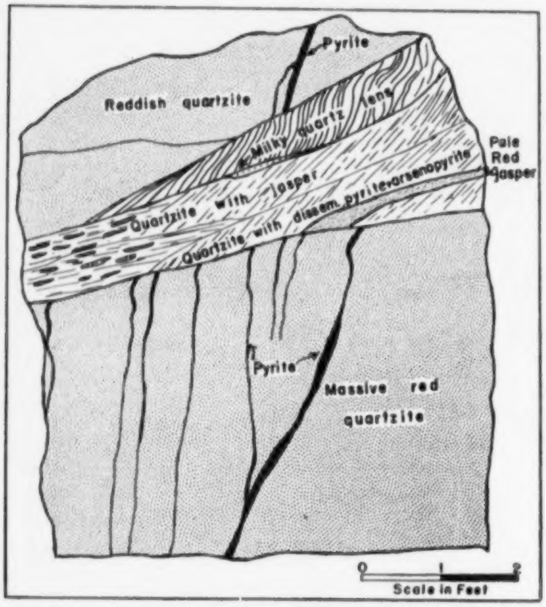


Fig. 5—Shear zone along a flat fault at the end of the northwest drift, 3100 level west, in the footwall area of the Sunshine vein.

Shear zones which may carry uranium mineralization are distributed throughout a total spread of some 200 ft wide. While they have offered favorable loci for the emplacement of uranium-bearing veinlets, the actual precipitation is erratic and considerable intervening non-mineralized areas exist. Fig. 8 illustrates shearing along a vein.

Fig. 9 illustrates an exposure showing several high grade uraninite stringers cut by a flat fault. The quartzite is intensely sheared and small fissure fillings containing uraninite are dispersed along fracture planes. Although cross-fractured, the veins have been only slightly displaced. In places the quartzite has

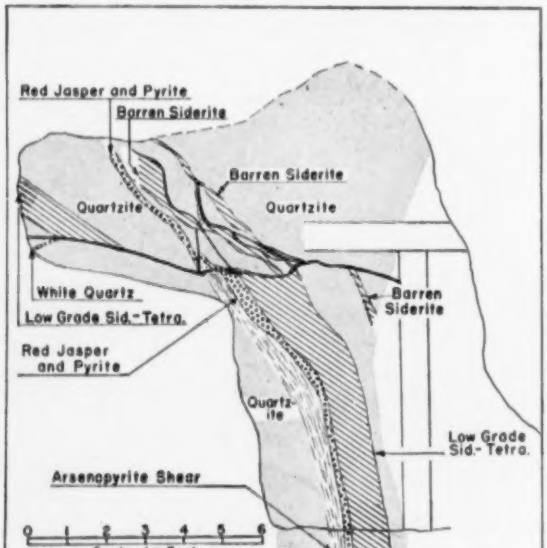


Fig. 7—The section shows an irregular flat fault displacing a low grade tetrahedrite-siderite vein and a shear zone containing arsenopyrite. East end 25 E. stope, 3250 level.

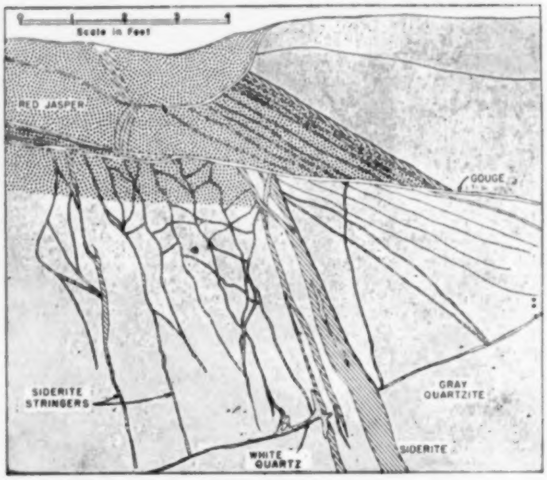


Fig. 6—Flat faults cutting the vein pattern.

been sheared and impregnated until it is locally an arsenopyrite schist. In a few places where arsenopyrite is abundant, orpiment has developed. Veinlet No. 1 in the diagram consists of red jasper, uraninite, and pyrite above a portion of a bedding fault opposite a siderite vein below. The thin veins, No. 2, consist of up to 3 to 4 in. of red jasper, uraninite, and pyrite both above and below a bedding fault. Pink quartz is present in the veinlets in the lowest part of the exposure.

The back of a stope in a plan view, Fig. 10, shows early diagonal cross fractures with uraninite veinlets and jasper having a diagonal trend along a cross shear pattern. Strike fractures followed with parallel movement furnish openings for siderite-tetrahedrite veins along the main shear. Late fracturing cuts all previous phases. Such field evidence indicates at least three main stages: early northwest shear, later east-west shear, and post mineral cross fracture.

Ribbon Structure

Banding with quartz or quartz and siderite veins forming a group of more or less parallel ribbons is a common feature in barren areas. Similar banding in uranium-bearing zones includes jasper and uraninite as well. A ribbon vein with associated uraninite is shown in Fig. 11. The ribbon structure consists of a succession of white quartz and siderite veins with border bands of pyrite-uraninite. A small, sinuous quartz vein containing galena and minor siderite was emplaced later. A similar ribbon structure mentioned above, Fig. 1b, is barren. The only feature which might give a clue to the proximity of nearby ore is dark gray quartzite with associated arsenopyrite.

Ribboned veins followed along the strike have led to uraninite-bearing zones, and in contrary manner, uraninite veins have merged into barren ribbon zones. The transitions may occur within a few feet. The sequence appears to be: main vein fracturing followed by deposition of arsenopyrite and pyrite; ribbon vein formation containing white quartz and siderite; late quartz filling which may be galena-bearing; and finally, late fracturing.

Age of Mineralization

Monzonitic rocks are exposed in an area north of Wallace, and dating of mineralization has previously

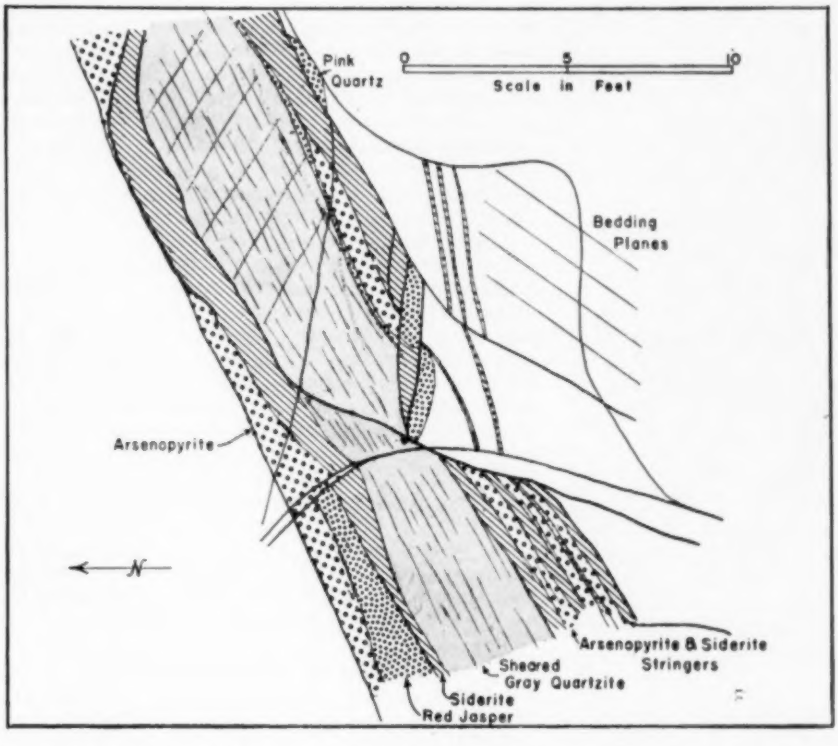


Fig. 8 — Section through 27 E. stope between 3250 and 3400 levels. Shows arsenopyrite vein borders, jasper carrying small amounts of uraninite, and siderite veins in an area heavily impregnated with arsenopyrite.

been based largely on the age of the intrusion. These rocks invade all members of the Belt Series except the Striped Peak. Anderson[7] concluded that monzonitic rocks, zones of bleaching, and mineralization in the Coeur d'Alene district all show intimate dependence on a deep-seated differentiating magma.

On the basis of both chemical and lead isotope analyses, J. Laurence Kulp has computed the age of Sunshine uraninite from the 3100 level as 750 $\pm$ 50 million years.[8] Further determinations will be required before the age of the uraninite may be considered other than tentative, but data now available favor a pre-Cambrian age.

Recently Anderson[9] has pointed out the existence of five metallogenic epochs in Idaho, namely, 1—late pre-Cambrian, 2—early Tertiary, 3—mid-Tertiary, 4—late Tertiary, and 5—Quaternary. He discredits the role of the Idaho batholith, late Mesozoic, as the most important mineralizer in the state.

Anderson considers that the monzonite of the Coeur d'Alene belongs to early Tertiary igneous activity and that the mineralization of the Silver Belt is related (p. 597 of ref. 9). The pre-Cambrian metallization is associated with the Purcell sills near the Canadian border. Copper deposits near Pocatello are also thought to be pre-Cambrian.

As the uranium mineralization is younger than the shears and fracturing in which it occurs, a pre-Cambrian age for the uraninite would date the folding as also pre-Cambrian. This is contrary to the

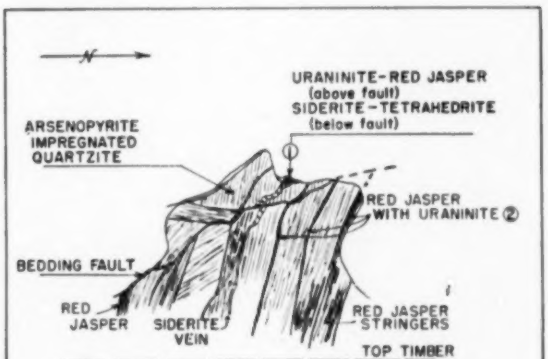


Fig. 9—Section shows sheared quartzite, impregnated with arsenopyrite and cut by uraninite veinlets. Although cross-fractured, the veins have been only slightly displaced.

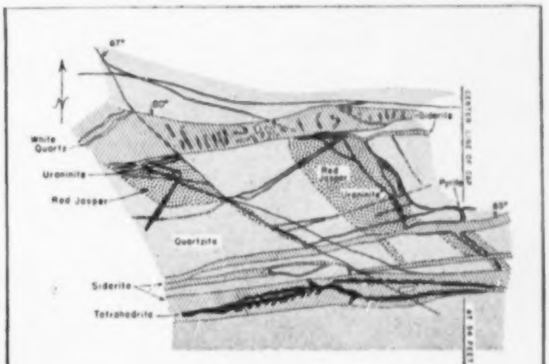


Fig. 10—Two intersecting zones of mineralization, 43 ft below 3100 level, west of Jewell crosscut. A north-west trending jasper zone and uraninite veinlets are cut by later east-west veins of siderite-tetrahedrite and siderite-quartz.

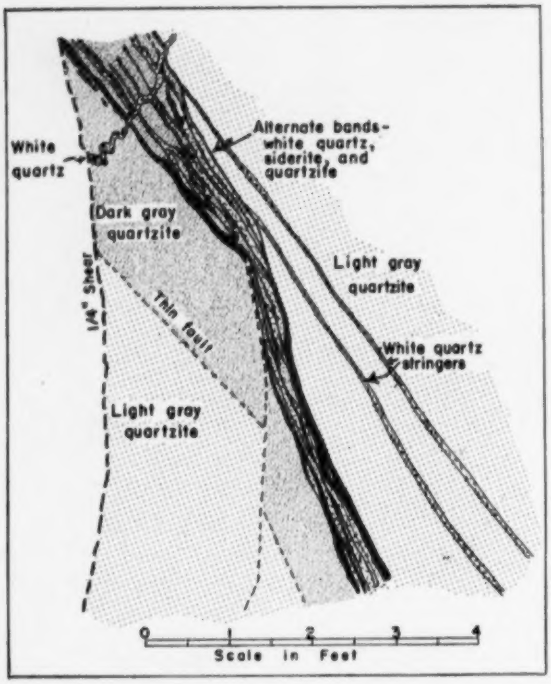


Fig. 11—A system of ribbon veins, 27 stope footwall crosscut, N-bearing 3400 level. The ribbon veins consist of alternate bands of white quartz and siderite, possibly with pyrite-uraninite.

customary interpretation which would place the folding in the Mesozoic. The segmentation of uraninite veinlets, the later infiltration of quartz around fragmented uraninite, the later reopening and sideritization of uraninite veinlets, and the truncation of uraninite veinlets by later siderite-tetrahedrite veins all point toward a later post-uraninite sulphide mineralization. It is not clear, however, whether the silver-bearing veins constitute a late phase of the pre-Cambrian mineralization or belong to one of the later epochs.

The Silver Syndicate fault furnishes evidence which may be significant. The gouge, the drag folds, and the shear have been replaced by the silver ore, and relict outlines are clearly preserved. The ore textures are unbroken by post-ore movement and indicate no major deformation since emplacement. Total absence of deformation along this structure since pre-Cambrian time seems unlikely. Yet later mineralization with an absence of more than minor differential movement since seems possible. At least one later epoch of mineralization probably occurred since pre-Cambrian. It seems likely that the Big Creek anticline as the major controlling structure dates to pre-Cambrian, but emplacement causing the heavy siderite veins and deformation responsible for certain major faults probably occurred later.

Types of Mineralization

Early Pyritic Veins

Massive pyritic veins with traces of fine disseminated uraninite occur near the top of the radioactive zone up to the 2900 level. Pyrite cements a vein breccia of angular quartzite. Later non-radioactive

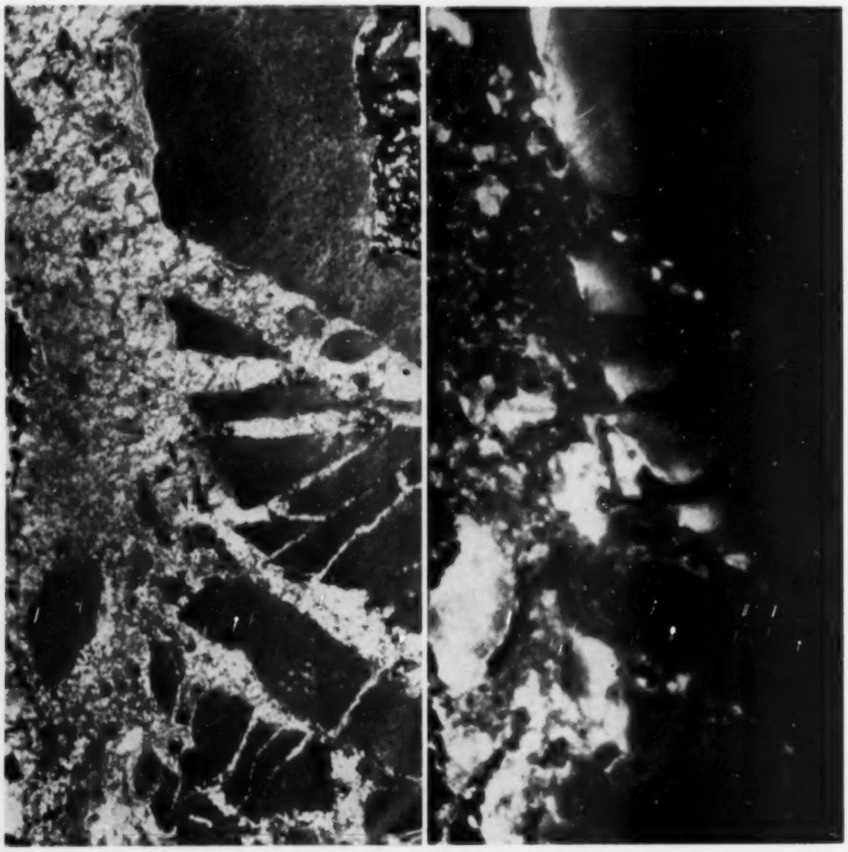


Fig. 12a — (Left) Early uraninite-pyrite vein, 3100 level drift, area shown is 3x6 in. Quartzite with disseminated uraninite (gray) forms a halo bordering veinlets of early pyrite (white). Fig. 12b — (Right) Radiogram of the portion of early vein shown in Fig. 12a.

siderite-tetrahedrite veinlets cut the earlier pyritic vein fillings. Halos of black smoky alteration mark pyritic margins and fade outward into the wall rock. Included quartzite fragments are also smoky in places. Most of the nearby quartzite is reddish brown. Disseminated through the halos are minute crystals of pyrite and other sulphides with scattered specks of uraninite.

A disseminated uraninite halo is shown in Fig. 12a, where the bright areas are pyrite and the darker areas are reddish brown quartzite, some of which is quite smoky. At the extreme left of the specimen, 12a, is a vein of siderite, in which there are small patches of tetrahedrite (black). In the radiogram, Fig. 12b, the uraninite lies both in brown quartzite and disseminated through the pyrite. The radioactivity is greatest in quartzite bordering the pyrite and absent in siderite.

Fig. 13 shows a specimen from the 3100 level, with a pyrite vein cutting across grayish brown quartzite. Specks of finely disseminated uraninite occur within the pyrite, but a more intense halo of radioactivity grades into the rock on each side of the vein. Clusters of fine metallic particles lie further removed in the quartz. Such phenomena indicate that part of the uraninite was an early phase, probably slightly earlier than the pyrite veins.

In Fig. 14 faults cut a pyrite-uraninite vein into two segments. However, vein filling closely resembling the vein pyrite-uraninite follows one fault plane, indicating that part of the faulting existed prior to emplacement. The main emplacement, however, was pre-faulting. Siderite veins, on the other hand, are truncated or displaced, and most of the fault movement is post-siderite.

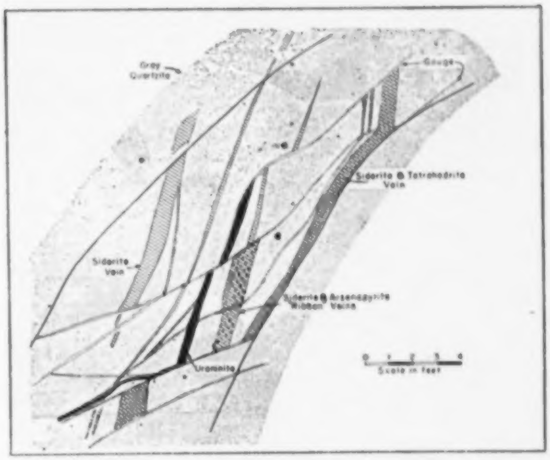


Fig. 14—A pyrite-uraninite vein is segmented in part by cross faulting and also follows a cross fracture.

Uraninite where most abundant occurs in veinlets consisting of intermixed red jasper, pyrite, and uraninite. Several types of associated pyrite are found. Finely crystalline pyrite occurs in at least two generations associated with uraninite. A more coarsely crystalline euhedral pyrite is usually of later origin.

Uraninite-Quartz-Pyrite Veins

Early uraninite may be cut by later silver-siderite mineralization, as shown by a specimen, Fig. 15, col-

Fig. 13 (Below)—Pyrite vein with uraninite halo, 3100 level, crosscut at 75,000. Area shown is 3x4 in. The pyrite veinlet contains specks of uraninite and is bordered by a diffused halo containing fine uraninite particles in quartzite.

Fig. 15 (Right)—Early uraninite (black) cut by late siderite (light gray), 25 E. stope, 3250 level, area shown is 3x8 in.

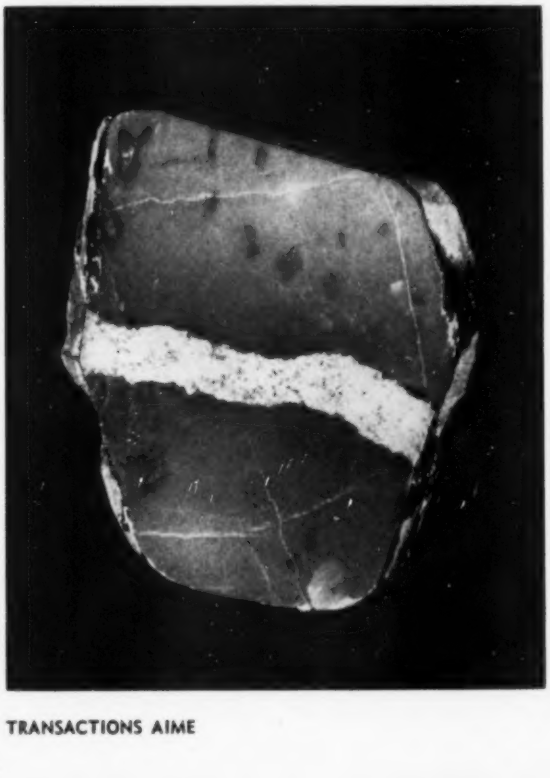


Fig. 16a (Left)—Red jasper cut by veinlets of pyrite mixed with and bordered by uraninite, 7th floor, 16 W. stope, 3100 level, area shown is 1.75x2.25 in. Fig. 16b (Above)—Radiogram of pyrite-uraninite veinlets in Fig. 16a.

lected at the junction of a uraninite shoot and a flat fault. Red jasper, fine-grained pyrite, and uraninite form an earlier vein zone cut by a vein of coarsely crystalline siderite and later pyrite with traces of tetrahedrite. It is a familiar mode of occurrence of uraninite at the Sunshine mine. The coarse-grained pyrite, which is late, is light in color. With the black uraninite there is a vein of earlier pyrite; this is fine-grained and dark in color.

Uraninite occurs along with massive pyrite in vein segments 2 to 4 in. across, see Figs. 16a and 16b, on several levels. Pyrite-uraninite veinlets are encased in red jasper. Fine-grained pyrite (white) is bordered and separated in places by uraninite (black). Thin veinlets of later tetrahedrite cut both the uraninite area and the jasper. The higher concentration of uraninite and absence of siderite indicate uranium precipitation accompanied by silicification prior to the main carbonate vein formation, see Figs. 12a, 12b, 13, and 15.

Thurlow and Wright (p. 401 of ref. 1) have pointed to the progressive replacement of quartz by uraninite. Pyrite appears to have been similarly replaced. However, specimens may be found in which uraninite formed both before and after pyrite. Pyrite intimately associated with the uraninite, however, is either fine-grained or colloidal in dimensions in contrast to coarse or euhedral pyrite of later origin.

Early observations by Thurlow and Wright (p. 404 of ref. 1) indicate that uraninite is a late mineral in the Sunshine deposit and presumably not subject to zonal distribution. On this basis it is concluded that uraninite would not be expected to become more abundant with depth. The current study would differ with the conclusions of Thurlow and Wright with respect to the relative roles of tetrahedrite and uraninite. Only occasionally is uraninite found in siderite veins associated with tetrahedrite. In such occurrences the uraninite is isolated and, it is believed, represents fragments transported mechanically from earlier masses as occasional quartz or pyrite fragments are transported, Figs. 17a and 17b. While recrystallization may take place because of the action of new fluids, and microscopic textures simulating replacement may result, the prevailing mechanism is one of mechanical transport.

Thurlow and Wright (p. 401 of ref. 1) interpret a small micro-area of tetrahedrite (X750) as undergoing marginal replacement by uraninite. However, it appears that the replacement is not entirely marginal and it is suggested that the uraninite itself may be in part replaced.

The few places where later uraninite veinlets have been observed constitute a comparatively minor feature. The current study would place emphasis on an early origin for most of the uraninite. If uraninite is an early mineral, as suggested, zonal distribution of uranium in relation to silver might indicate greater concentration at a lower level.

Segmentation: The uraninite veins are ordinarily short segments, at most only a few feet long and often not more than a few inches in length. Even under the microscope, Fig. 18, colloidal aggregates of uraninite are segmented and parted by quartz.

Segmentation as shown in a stope is illustrated in Fig. 10. Northwesterly earlier uraninite segments are cut by siderite veins with an easterly normal strike. Further segmentation appears in Fig. 14. Localization accompanies segmentation as shown in Fig. 9. Although the veins may be observed to extend for several feet in the exposure, the chief ore-bearing lenses are 3 to 4 in. thick at the widest portion and taper to a fraction of an inch within a foot.

Lateral Variation: The groups of parallel veins and stringers which make up the vein zone vary from hanging wall to footwall. Solid siderite may occur on one side with strong uranium mineralization opposite, or various other combinations may be found. The veins shown in Fig. 10 vary from side to side. On the north side a siderite vein contains quartz

Fig. 17a—Streaks of uraninite in a siderite vein, 3100 level W.

Fig. 17b—Radiogram of Fig. 17a. Size 2.25x3.25 in.

segregations but no tetrahedrite. On the south side a parallel siderite vein is rich in tetrahedrite.

Siderite-Uraninite Occurrence

The siderite-uraninite relationship in the Sunshine mine is a matter of interest. Usually uraninite occurs in portions of veins where siderite is absent, but occasionally the two are found in close proximity. Whether the uraninite found with the siderite represents a later generation or whether it is merely reworked material that has been transported more or less mechanically is not always certain.

An illustration of the uraninite-siderite association is shown in Figs. 17a and 17b. The succession of vein opening and filling is complex. The lower half of the specimen consists of jasper formed with the fine quartz impregnated with finely crystalline arsenopyrite. The upper half of the specimen consists of successive bands of siderite; uraninite; pyrite; mixed siderite, pyrite, and uraninite; pyrite; and siderite containing pyrite and tetrahedrite.

Siderite is the prominent gangue mineral of the Coeur d'Alene silver veins. It may occur alone or impregnated with varying amounts of silver-bearing tetrahedrite. Massive veins may be observed with the hanging wall type of siderite, heavily mineralized with tetrahedrite. White quartz, apparently unmineralized, may occur in isolated patches. Evidently such veins do not bear uraninite.

Manganese is a prominent constituent of the carbonate, as shown by X-ray fluorescence curves. Small amounts of other elements may be present but do not yield peaks above background. Calcium and magnesium were determined for a considerable number of carbonate samples by Mitcham.[9]

Thermal curves, Fig. 19, of siderite from the Sunshine mine yield an endothermic peak between 500° and 550°C, followed by a variable exothermic peak, ranging from 550° to 620°C.

Among the siderite samples chosen for thermal analysis were: a sample from a stope closely associated with red jasper, pyrite, and tetrahedrite (3250 level, 25-ft stope raise); a sample from a stope containing siderite and tetrahedrite (31 to 16 W, 3rd floor); a sample of siderite mixed with quartz, pyrite, and tetrahedrite (Sunshine vein, 3100 level at junction of Jewell crosscut and main drift); a sample of siderite closely associated with uraninite (2nd radioactive vein, 3000 level); a sample of siderite associated with pyrite, quartz, and uraninite (3400 to 25 stope, 30 ft below 3250 level); a fairly clean sample of siderite with stringers of white quartz (3250 level, 25 E stope).

The samples selected were as clean as possible, but in most cases small amounts of fine-grained pyrite were present. Several reported variations in thermal curves of siderite may be due to varying particle size and tightness of packing, according to Rowland and Jonas.[10] The thermal curves for sid-

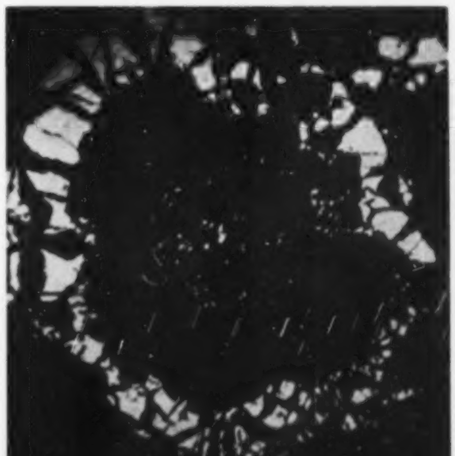


Fig. 18—Micrograph of a polished surface shows colloform uraninite forming a circular group of segmented fragments in a gangue of red jasper. X120.

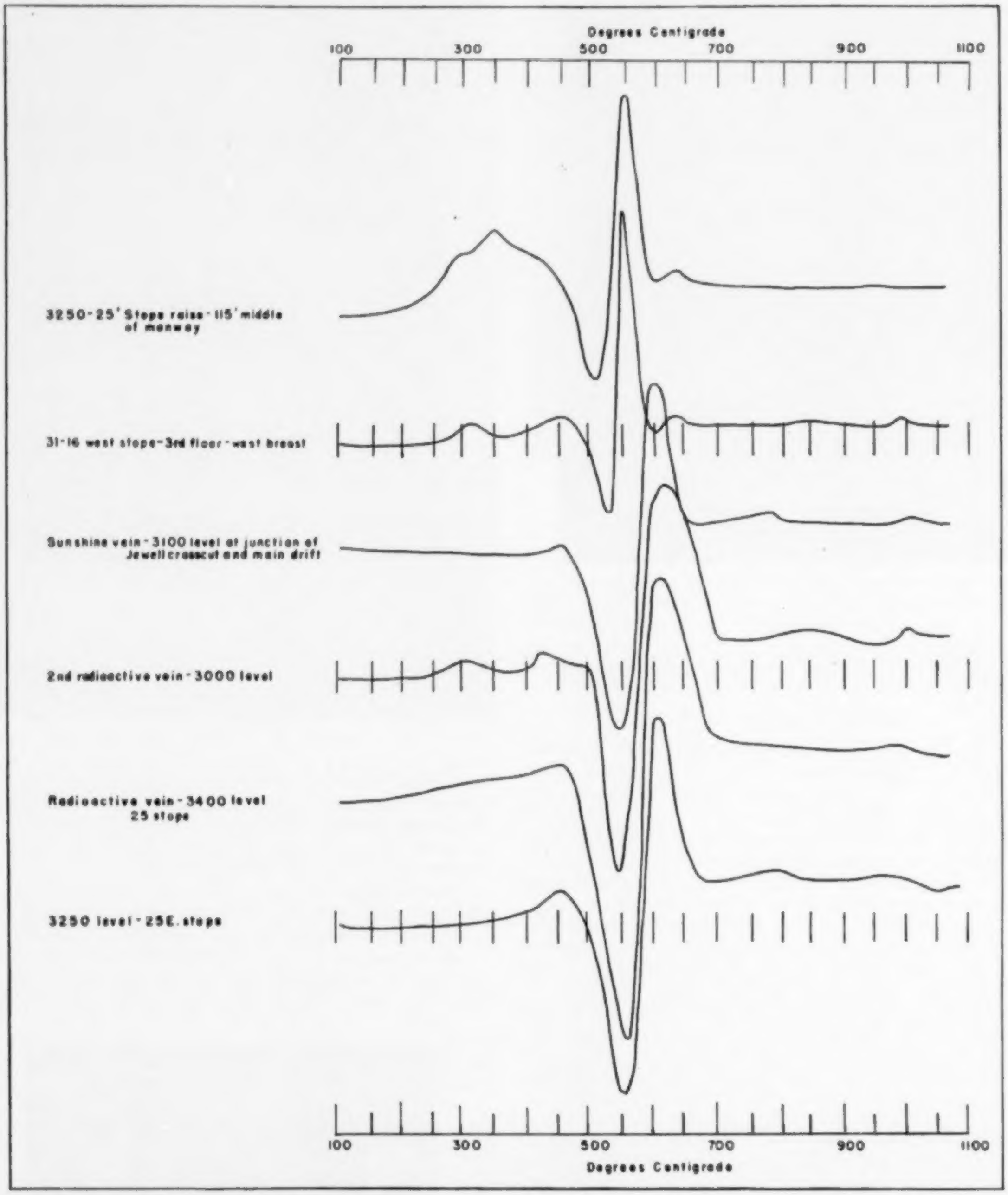


Fig. 19—Thermal curves of siderite from the Sunshine mine yield an endothermic peak between 500° and 550°C, followed by a variable exothermic peak, ranging from 550° to 620°C.

erite from the Sunshine mine are essentially the same whether the mineral is associated with uraninite or tetrahedrite or found in barren veins.

A specimen with a siderite vein bordered on each side by a thin streak of uraninite is shown in Figs. 20a and 20b. A color rim of red jasper immediately borders the uraninite. Apparently the fissure has been subjected to filling, reopening, and refilling; an earlier uraninite phase formed with a smoky border was later reopened and a later siderite phase was introduced.

Pyrite-uraninite veinlets bordered by uraninite halos and jasper are shown in Figs. 21a and 21b. These veinlets are truncated at an oblique angle by a larger and later vein composed chiefly of siderite. A few scattered patches of tetrahedrite occur in the siderite vein but none were observable in the diagonal veinlets.

Many occurrences may be found in which it appears that siderite veins were formed at an early stage. Such veins are usually much thinner than siderite of later origin. Other criteria consist of more extensive fracturing, segmentation, and intersections with later siderite, as well as structures indicative of reopening and filling.

Fig. 22 represents two generations of siderite, both forming steep veins; a later finer-grained brown siderite forms veins a foot thick, whereas

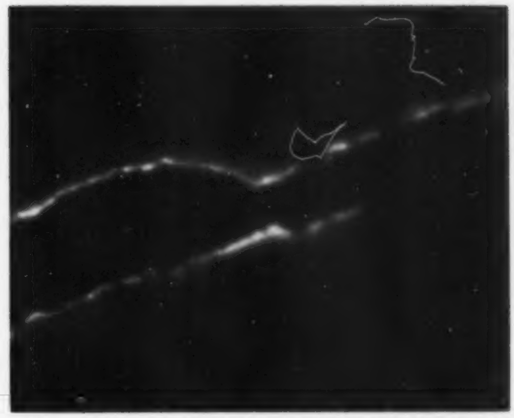


Fig. 20a—Siderite vein with uraninite margins, 25 E. stope 40 ft below level, area shown is 4.5x5.5 in. An earlier uraninite vein apparently was reopened and siderite deposited in the center. Fig. 20b—Radiogram of Fig. 20a.

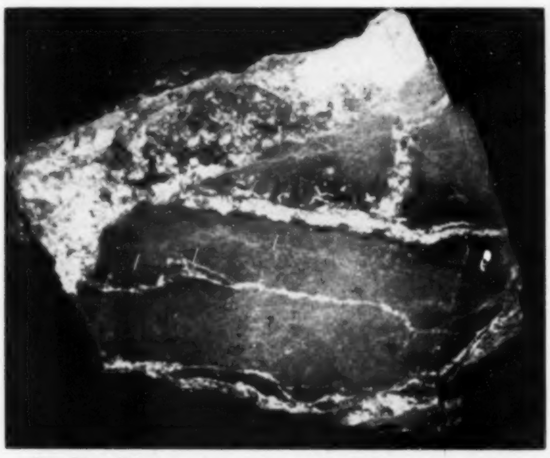
earlier coarser veins are thin. Quartz ladder veins lie in the thick veins in fractures due to shrinkage or tension. A single remnant stringer of coarse brown siderite is enclosed in the thicker hanging wall siderite vein. The following sequence may be inferred: 1—bedding shear and fractures filled with earlier siderite; 2—associated red quartz accompanying nearby uranium introduction; 3—later siderite veins; 4—white quartz filling cracks in later veins; late fractures.

One such earlier vein may be seen in the area between the Sunshine and Chester veins, Fig. 23. Here a vertical siderite vein has been terminated by the uraninite-bearing jasper, while siderite stringers, presumably filling tension cracks, appear to be later. The jasper-uraninite mineralization followed the vertical siderite and presumably preceded the siderite stringers. A nearby white quartz vein is isolated but is probably later.

In a number of specimens uraninite is concentrated along the margins of tetrahedrite-siderite veins or siderite veins as already mentioned, see Figs. 20a and 20b, 21a and 21b, and 23. In such specimens the original fracture carrying uraninite appears to have been reopened and filled with siderite. A late siderite vein may be seen along the 3100 W. drift, Fig. 24, some 3 to 6 in. thick, which penetrates a red jasper area containing disseminated uraninite. The siderite vein itself contains a ladderlike pattern of quartz veins. Uraninite along the brecciated zone illustrated in Fig. 23 shows a later siderite cutting jasper and earlier uraninite. The various features of a uranium-bearing zone cut by non-radioactive siderite-tetrahedrite veins are illustrated in Fig. 25.

Variation in the tetrahedrite content of siderite veins is noteworthy. Frequently, as shown in Fig. 10, one vein of a group may contain all or nearly all of the tetrahedrite for a cluster of several veins which vary in size. Such tetrahedrite-bearing veins are ordinarily subsequent to the uranium mineralization and cut areas of red jasper. Tetrahedrite ore normally occurs in a filling in coarse siderite veins. Small patches of pink quartz are occasionally associated with such veins or even minor amounts of uraninite, but for the most part coarse tetrahedrite-siderite veins are free from uranium.

The minerals of the Coeur d'Alene have been listed by Mitcham.[9] Few sulphides in addition to pyrite and arsenopyrite are found in the uranian area. On the 3400-level crosscut to the Chester vein, see Fig. 23, surrounding small uraninite concentrations, is an irregular mass of red jasper containing disseminated chalcopyrite, tetrahedrite, and uraninite for a width of 18 to 20 in. A specimen from the 3700 level, Jewell crosscut vein, shows multiple



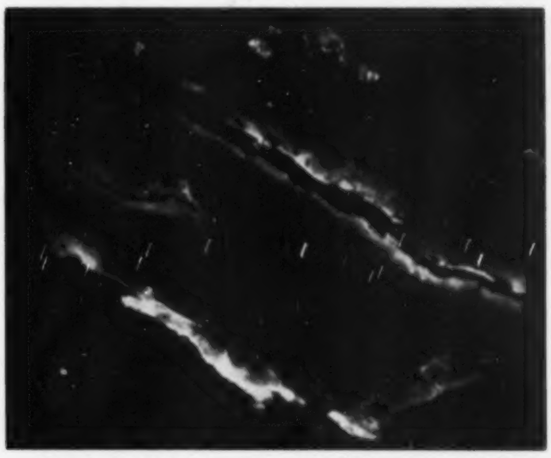


Fig. 21a—Siderite vein cutting early pyrite-uraninite veins. Area shown is 4.5x5 in. Fig. 21b—Radiogram of Fig. 21a

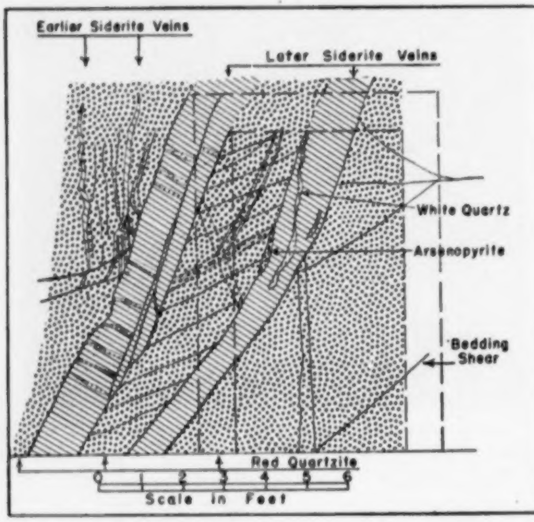


Fig. 22—Two generations of siderite veins, S. W. face, 16W. stope, 3100 level, 3rd floor.

stages of pyrite, quartz, siderite, and some stibnite. Another from the 3700 level shows a red quartz-siderite-pyrite vein containing galena, cutting black radioactive carbonate, and pyrite, Figs. 26a and 26b. This specimen is unusual because in this instance galena is found in a vein cutting a radioactive zone. As may be seen from the radiogram, the uraninite is intimately mixed with the carbonate and pyrite on each side of a galena-bearing vein, but the vein itself is not radioactive.

Unmineralized white quartz occurs in ribbon veins, Fig. 2b, where it is probably contemporaneous with uraninite-bearing quartz, Fig. 2a. It also occurs in cracks, see Figs. 22 and 24, within siderite veins. A later generation, Fig. 6, with minor galena, occurs as crosscutting veinlets. A white quartz veinlet about an inch thick and crenulated in outline with scattered small patches of galena may be observed in Fig. 11 cutting earlier ribbon vein structures at right angles.

An unusual white quartz vein containing galena and boulangerite (?) occurs along the uraninite-bearing zone on the 3700 level. The quartz vein is parallel to the main vein for the most part, but gradually cuts across the course of the uraninite vein. It may represent a change in mineralization with depth, since galena-bearing veins are unusual at higher levels in the Sunshine mine.

Thin white quartz veins about ¼-in. thick may occur in parallel lines isolated from the main vein in the footwall. Such barren veins occasionally lie close to parallel veins containing siderite and tetrahedrite.

Indications of Uranium Mineralization

Certain significant characteristics accompanying the uranium deposition are indicative of mineralized zones, the most striking being the stain of red, brown, or pink in finely crystalline silica near uraninite. Radioactivity along fractures and in gouge is also indicative, but it may not lead directly to ore, since with available equipment radioactivity may be detected in concentrations considerably below present mining limits. Another feature is the association of arsenopyrite. Where arsenopyrite is abundant, either high uranium or high silver or both are usually found. Presumably, arsenopyrite was one of the early sulphides and was precipitated in heavy concentrations within a comparatively narrow range.

Coloration in Crystalline Silica

The red alteration or the so-called jasper has not yet been adequately explained, but in the Sunshine mine several features appear to be established.

Repeated association of red with uraninite and the absence of coloration where uraninite is not found demonstrate that the jasper and uraninite are related. Also the color is always confined to a siliceous matrix, the silica being microcrystalline to colloidal. The jasper zone varies from a fraction of an inch to several inches in width and is a localized phenomenon, see Fig. 27.

The jasper has long been noted by the miners in the Sunshine mine, although uraninite itself was not recognized until recently. It has not been reported from the levels above 2900. While geiger counters were not available when the upper levels were mined, it is probable that the red halos, had they existed, would have been observed when the rock was freshly broken. The zones of red alteration indicated by exposures along drifts, in crosscuts and cores from drill holes, see Fig. 28, form a broader and more regular pattern than the corresponding uranium occurrences, Fig. 3. The pattern of the red zones suggests close folding in the St. Regis quartzite on the 3100 level west of the Jewell crosscut. Aside from an occurrence in the Jewell crosscut, 150 ft from the Sunshine vein, and a sporadic occurrence at the east end of the workings, Fig. 28, the red alteration lies on the south limb of the minor anticline as indicated in Fig. 3. A 45° drill hole driven southward at the west end of the 3100 drift encountered red alteration, at 36 to 59 ft, although a nearby horizontal hole driven in the same direction failed to encounter the alteration. The zone is believed to show a rake to the west under the second drill hole.

In general, depth of color increases with uranium concentration. Several dozen fragments selected to show the entire range of color were examined with a geiger counter. With few exceptions which could be explained by variations in size, the highest counts were given by the most highly colored lumps and

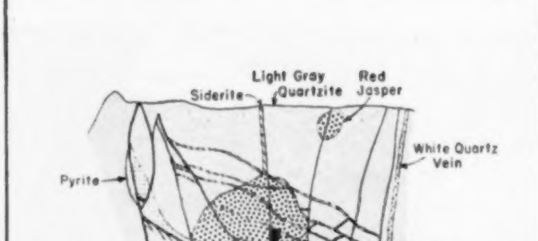


Fig. 23—Uraninite occurrence from a brecciated zone about midway between the Sunshine vein and the Chester vein. It represents both pre-siderite and post-siderite deposition.

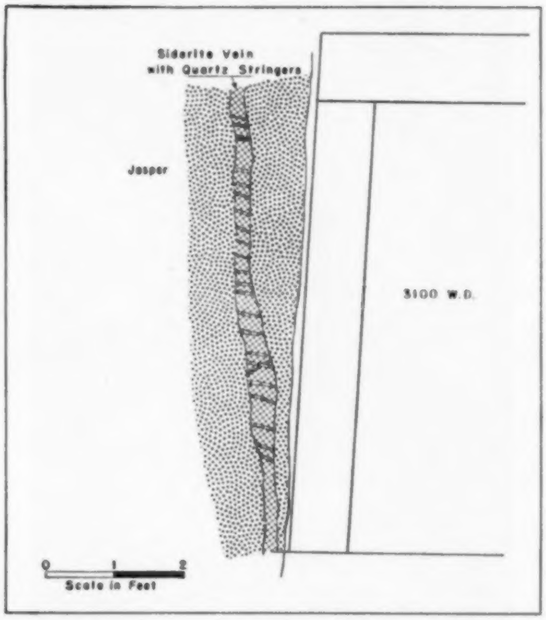


Fig. 24—Ladder quartz in a late siderite vein 3 to 6 in. thick, which penetrates a red jasper area containing uraninite.

counts decreased with a decrease in the intensity of color.

When the jasper is examined with the microscope it is found to contain disseminated grains of metallic minerals. Most abundant are disseminated grains of sulphides, chiefly pyrite, but scattered grains of uraninite are more plentiful in areas where the color is most intense. Other fine sulphide grains are arsenopyrite, Fig. 29, sphalerite, and chalcopyrite. Occasionally larger patches of tetrahedrite may be observed, but these appear to follow fractures and probably represent later introduction.

The pigment responsible for the color is fairly uniformly distributed and resembles the red of agates artificially colored by absorption of ferric hydroxide followed by roasting. A possible explanation would be that a small amount of ferric oxide formed contemporaneously with uraninite is absorbed in the finely crystalline or colloidal silica of the matrix.

Red alteration is characteristic of the borders of uraninite veins at Great Bear Lake, in the Beaver Lodge area and elsewhere in Canada. Dawson[11] has attributed the red color associated with uraninite at Ace Lake to fine hematite distributed through oligoclasite. The fine-grained siliceous rocks of Canadian areas are often comparable in color to the Sunshine material. The alteration is also accompanied in many cases both by an increase in iron content and radioactivity. The mineral carrying the uranium is uraninite, or pitchblende, and the iron is ordinarily present as hematite. While this is a general feature for Canadian occurrences, exceptions have been noted.

Specimens collected on the 3100-level drift, at about 75,000 E, show pink quartz. A hanging wall siderite vein contains brecciated carbonate with streaks of pinkish quartz cutting the carbonate and apparently replacing it. The pink quartz carried small amounts of carbonate which may be of a different type. Veinlets containing the quartz are discontinuous and lenticular and contain little uraninite. Black fractures in the specimens are limonite-filled. White quartz is present in the siderite, but there is apparently no metallic mineralization associated with the white quartz of this type. It would seem that white quartz forms areas of little uranium or silver mineralization.

Occasionally smoky black halos of alteration occur along pyrite-uraninite veinlets, the halo fading into gray-brown jasper. Both the halo and the veinlets may be cut by siderite veins which contain isolated patches of tetrahedrite but no uraninite. Disseminated uraninite with less hematite appears to give the halos a smoky appearance.

Arsenopyrite Zones

Arsenopyrite frequently accompanies the uranium-bearing veins. It may be present as an earlier vein filling disseminated throughout the quartzite, Fig. 9, or in masses along vein borders. Although associated with siderite in some earlier phases, it is more commonly found with quartz. Where evidence of sequence is available, it is pre-uraninite. Mitcham,[8] in a study of the tetrahedrite veins of the Silver Belt, looks upon arsenopyrite as an indicator mineral in connection with silver orebodies. Evidence from sections examined in connection with uranium mineralization would point to a similar significance as an indicator for uranium deposition.

Fig. 25 — Uranium zone cut by silver zone, 3rd floor, 16 W. 3100 level. Earlier uraninite veinlets bordered by jasper and disseminated arsenopyrite in quartzite are cut by later nonradioactive siderite-tetrahedrite veins bearing silver.

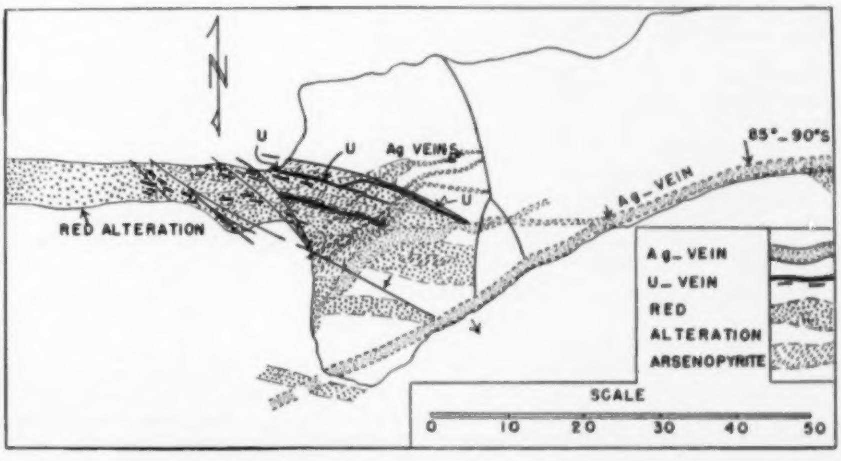


Fig. 26a—A red quartz ankerite vein containing galena cutting black radioactive carbonate, 3700 level about 4 ft East of Jewell crosscut. Area shown is 3.5x8 in.

Fig. 26b—Radiogram of Fig. 26a.

Where arsenopyrite is abundant, solutions responsible for early stages of vein mineral precipitation contain a high concentration of metallic elements. Thus in the vicinity of such places it might be expected that there would be massive pyritic veins and the heaviest concentrations of uraninite. This may be one occurrence of uraninite, but examination of several specimens would indicate that uraninite is distributed widely and many times occurs in places devoid of arsenopyrite.

Arsenopyrite may occur in minute crystals both in the quartzite of the vein walls and in the veins themselves. Wall rock fragments, Fig. 16a and 16b, isolated and partly replaced by pyrite and siderite masses, are in places impregnated by arsenopyrite. At one place in a zone of fracture cleavage, Fig. 9, arsenopyrite is distributed in the footwall locally forming an arsenopyrite schist. Some of the lenses of uraninite are well developed at this point. Arsenopyrite is usually unaltered, but occasionally, in old workings, a secondary yellow mineral resembling orpiment has developed. A prominent arsenopyrite-uraninite association is shown in Fig. 8. Here substantial veinlets of uraninite were observed. Further, both the footwall of the vein area and a streak along the hanging wall for a distance of 25 ft are impregnated with arsenopyrite.

A significant feature in mineralization observed in places along barren ribbon veins which might give a clue to the proximity of nearby uranium concentration is dark gray quartzite impregnated at times with arsenopyrite.

Disseminated arsenopyrite, Fig. 25, appears related to the uranium zones at times, but not to the silver zones. The trend along uraninite stringers is cut by silver veins. Arsenopyrite areas also appear to be encircled by red alteration.

Arsenopyrite vein stringers are shown in Fig. 8. Here both the footwall of the vein area and a streak along the hanging wall for a distance of 25 ft are impregnated with arsenopyrite. The exposure indicates vein shearing and fracturing, followed by arsenopyrite vein filling. Then comes uranium-bearing red jasper, siderite veins, and post vein fractures.

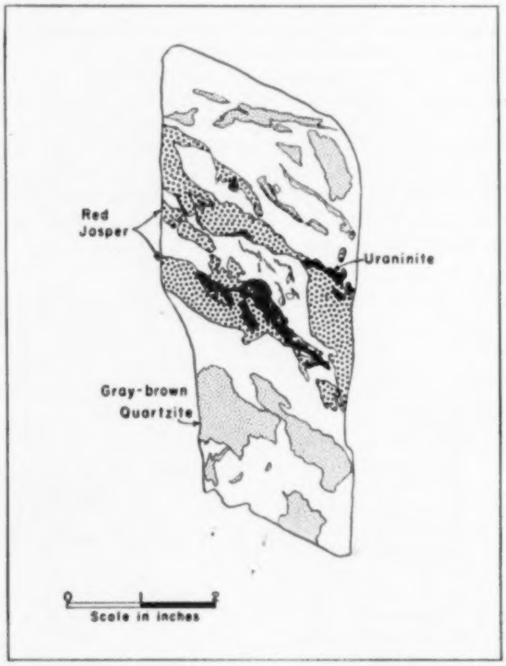


Fig. 27—Specimen diagram of jasper-uraninite association in quartzite, uraninite (black), red jasper (dots), and grayish-brown jasper (stippled). Streamers of pyrite are visible in the uraninite.

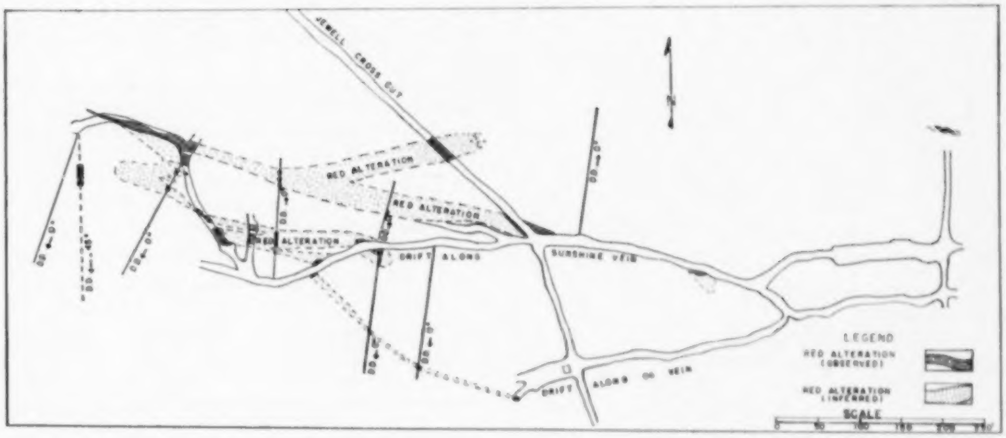


Fig. 28—Red alteration along 3100 level. Observed zones of red alteration jasper are shown in relationship to inferred zones based upon exposures in the workings and drill cores.

As previously noted, the presence of uranium was first detected through a reconnaissance survey with a geiger counter. Since then workings have been surveyed with geiger counters, and where possible drill holes have been examined with radioactivity detection devices. These studies have outlined the radioactive area.

Radioactivity

A radiometric diagram of the 3100 level, Fig. 4, shows seven positive anomalies with gamma counts exceeding 500 per sec; two occur along the Jewell crosscut and five along the west drift. An abrupt change from high to low radioactivity across shear zones appears in two places. At one, west of No. 4 shaft, a low angle bedding plane fault terminates the uranium-bearing zone. Red alteration and higher counts occur above the fault and to the west, while below the fault and to the east the count is low and red alteration is absent. At another, N 40° to 50°W, shear 80 ft west of the Sunshine-Jewell intersection locally limits westward extension of red alteration in the 3250 to 25 E stope 25 to 50 ft below the point.

Contour readings are given as low as 30, but the normal background is 50 to 60 counts per sec; hence it is not likely that such low contours are significant. The radiometric diagram is based on a scintillometer survey by R. F. Robinson, M. Reyner, and J. Coulson. Readings were taken at 5-ft intervals in areas of high values, but at 25 ft elsewhere.

While the radiometric diagram is inadequate to justify quantitative application, it reveals a pattern which corresponds in general to distribution and red alteration of uranium mineralization. It also emphasizes the localized nature of the radioactivity.

Uraninite: Analytical Data

Through the cooperation of the Division of Raw Materials, AEC, both chemical analyses and lead isotope analyses of uraninite from the Sunshine mine have been secured. The material analyzed was collected on the west face of No. 16 stope, 3100 level, west of Jewell crosscut. X-ray data on the uraninite yield a lattice constant of 5.444 A. Table I gives the indexed powder data, in A* units, for the uraninite from the Sunshine mine.

* X-ray measurements are given in terms of Angstrom units based upon Siegbahn's wave lengths.

Table I. Analysis of Uraninite, in A Units, From Sunshine Mine

I	2θ (Cu)	d(A)	(hkl)
100	28.68	3.116	(111)
50	33.24	2.692	(002)
80	47.51	1.912	(022)
80	56.28	1.631	(113)
20	58.94	1.565	(222)
10	69.30	1.354	(004)
30	76.32	1.246	(133)
30	78.77	1.41	(024)
30	88.04	1.108	(224)
30	94.80	1.046	(333), (115)
10	106.62	0.961	(044)
40	113.88	0.919	(135)
20	116.14	0.908	(006), (244)
20	127.11	0.860	(026)
20	136.27	0.830	(335)
20	139.63	0.821	(226)

The sample analyzed was hand-picked but in view of the impurities shown in the analysis must be assumed to have contained pyrite, siderite, tetrahedrite, quartz, and sericite. The determinations re-

Fig. 29—Micrograph of rhombic sections of arsenopyrite in quartz. Vein pyrite is transected and replaced by numerous quartz veinlets, which in turn are replaced by arsenopyrite.

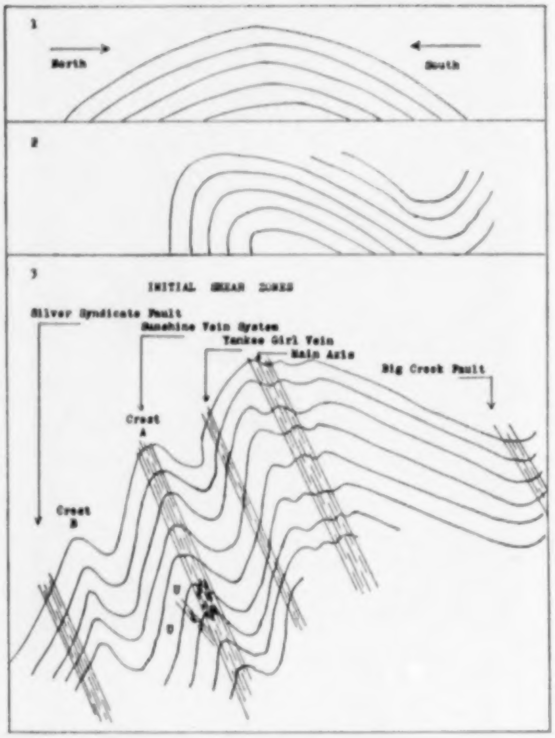


Fig. 30—Initial folding and fracturing, sectional diagram.

ported by Clara Gale Goldbeck of the New Brunswick Laboratory, AEC, are given in Table II.

Table II. Chemical Analysis, Sunshine Mine

Item	Pct
U_3O_8	26.9
PbO	4.0
SiO_2	18.2
Al_2O_3	4.4
Fe	13.1
CaO	.8
Mn	1.0
Cu	7.7
Ag	1.0
Sb	2.6
H_2O	1.1
CO_2	6.8
S	9.0

Isotope analyses of the uraninite, secured through the cooperation of Roger Hibbs, Carbide and Carbon Chemicals Co., Oak Ridge, and reported by Kerr and Kulp,[8] are shown in Table III.

Sequence of Emplacement

The emplacement of the ores of the Sunshine mine has consisted of a complex process of successive fracturing and filling. Sections and specimens, however, provide data from which the major sequence may be interpreted, see Figs. 30 to 32.

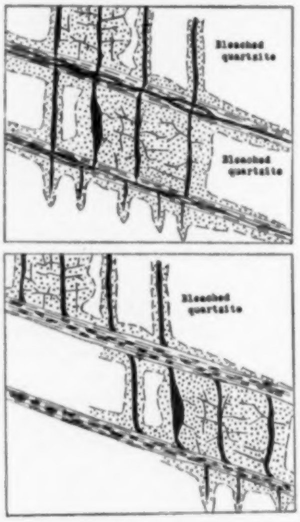
Deformation of the Beltian sediments provided the major structural features along which ore emplacement of both the silver and uraninite ores has taken place. As a result of major compression, Fig. 30, steeply inclined fractures, zones of fracture cleavage, local folds, breccia, cross faults, and bedding plane slips were developed, all of which participated in one way or another in providing channels for the penetration and localization of the ore-forming fluids.

The steeply inclined fractures have provided loci for the precipitation of silver ores, but the uraninite has shown less limitation to the major vein fractures. Above the 3250 level at least uraninite has favored shear zones related in a number of instances to fracture cleavage. On the 3700 level, however, the occurrence is largely restricted to a fissure vein.

Table III. Lead Isotopes, Sunshine Uraninite

208	17.84 ± 0.07	0.460 ± 0.013	50.67 ± 0.05
207	12.42 ± 0.05	7.32 ± 0.02	20.69 ± 0.03
206	69.20 ± 0.03	92.17 ± 0.01	27.27 ± 0.05
204	0.540 ± 0.010	0.044 ± 0.001	1.37 ± 0.02

The first stage in uranium mineralization appears to have been the precipitation of uraninite along with pyrite under more or less colloidal conditions. In places arsenopyrite and pyrite penetrated the quartzite of the wall rock at about this stage. At the peak of emplacement quartzite close to areas of uraninite precipitation was recrystallized and permeated by hematite and minute specks of uraninite resulting in a red halo. Little siderite appears to have developed where this process was most intense.



A—Diagram showing uranium mineralization on the south flat limb of minor anticline at the conclusion of uranium emplacement and red alteration.

B—Diagram showing uraninite stringers and zones segmented by bedding plane faulting due to continued anticlinal folding prior to Sunshine vein silver deposition.

Fig. 31—Uraninite segmentation along flat faults.

Following the main emplacement, the uraninite-bearing areas were subjected to faulting and in the main the early epoch of pyrite-quartz-uraninite mineralization appears to have been succeeded by the gradual development of strong carbonate veins accompanied by argentian tetrahedrite.

No clear lines of demarcation appear to separate the two epochs. Some siderite and a little tetrahedrite may be found in veinlets associated with early uraninite. Likewise fragments of uraninite and some streaks of radioactive material may be found at times in tetrahedrite-siderite veins. In general, however, the weight of evidence provided by sections and specimens points to an earlier uranium and a later silver epoch.

Deformation features following the second metallic epoch are less clearly defined but are shown by

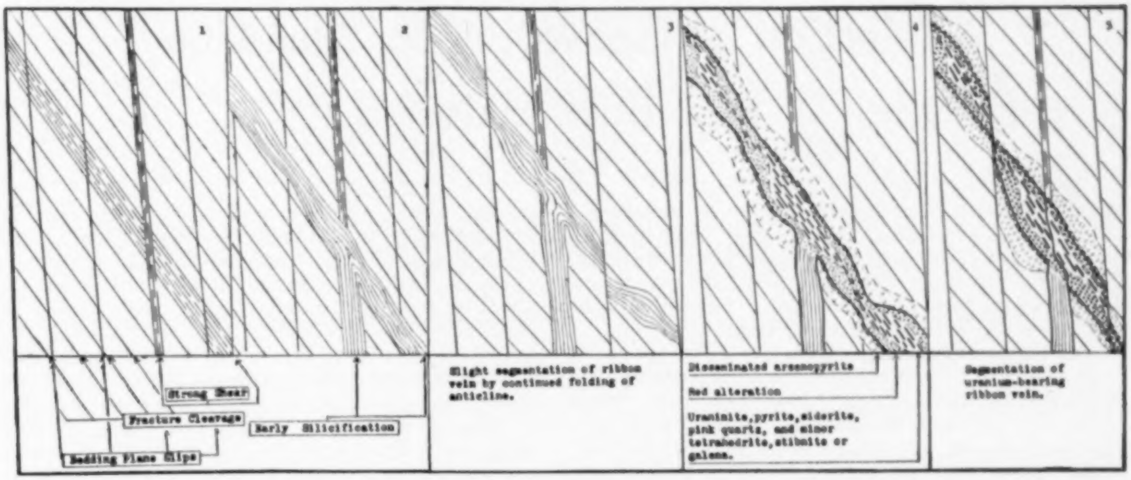


Fig. 32—Sections 1 and 2 show fracture cleavage and bedding plane slips with shearing and silicification as developed on the north limb of the overturned anticline on the 3700 level. Sections 3 to 5 illustrate the development of a ribbon vein carrying uraninite by replacement along a silicified shear zone with subsequent segmentation.

displacements along siderite-tetrahedrite veins and crosscutting structures. The same may be said for the post galena-quartz deformation.

The principal epoch of deformation after the start of mineralization appears to have followed the uraninite-pyrite stage and accompanied the introduction of siderite and tetrahedrite. While many small cross faults were formed by the inter-epoch movements and frequent reopening along vein courses resulted, the movements were seldom large, often being measured in inches and only occasionally more than a few feet.

In summary, the main sequence of events accompanying mineralization in the uraninite area may be interpreted as follows:

1—Regional deformation of Beltian sediments: major anticlinal structure; faulting along north limb; bedding slips, fracture cleavage; shear zones. 2—Early uraninite-pyrite-quartz emplacement accompanying arsenopyrite in wall rock: red halos in areas of greatest concentration; colloidal effects; some early siderite. 3—Intermineralization deformation: vein reopening and parallel fracturing; bedding plane, and *flat* faults; segmentation of uraninite veins. 4—Main tetrahedrite-siderite epoch: major silver veins formed; some solution and reprecipitation of uraninite. 5—Post silver deformation: parallel fracturing on a minor scale; limited cross faulting. 6—Quartz-galena stage: barren or low grade siderite veins; quartz-galena veins; white quartz veins. 7—Post mineral deformation.

Acknowledgments

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Selection of Conveyors for Handling Hot Bulk Materials

by J. Walter Snavely

PRESENT-DAY processing in many industries, calcining, sintering, briquetting, beneficiation and nodulizing, increasingly calls for the handling of large volumes of hot bulk materials. Various types of conveyors have been employed. This discussion will cover the factors governing their selection.

For temperature ranges up to 400°F, or approximately 200°C, a wide range of conveyors is available. Special constructions of rubber conveyor belts, steel conveyor belts, vibrating and shaker conveyors, apron conveyors, and drag chain conveyors, all are used successfully. As temperatures go well above 400°F, however, choice of conveyors is narrowly limited. This paper will consider the problem of handling bulk materials only where the temperatures exceed 400°F.

The arbitrary selection of 400°F as a dividing point undoubtedly can be challenged, as special conveyor belting constructions are available which are suitable for temperatures in excess of 400°F. However, when the relatively short life of such belts and the cost of their replacement, with the attendant down time, are balanced against the reliability and long service life of the properly designed steel constructed units to be discussed, there is little question in any operator's mind that the special belts are more expensive to use.

Because the conveyors under study are for the handling of bulk materials, inevitably including a high proportion of fines, obviously wire mesh belts cannot be included for consideration. Even though this type of conveyor is widely used at high temperatures, i.e., for carrying glassware through a lehr, it is unsuited for the conveying of bulk materials, and therefore will be excluded from further discussion in this paper.

Preliminary to the study of the conveyor itself is the determination as to whether the material is to be cooled while it is being handled, or whether the processing requires retention of all heat and the maintenance of a given temperature range.

In the majority of cases cooling is incidental to or part of the handling process, when the handling, for example, follows completion of sintering, roasting, calcining, refining, or some other process. To meet such operating conditions successfully, the conveying medium used must have: 1—a construction capable of withstanding maximum initial temperatures of the material being handled, 2—a construction providing efficient heat transfer for cooling. 3—a construction providing dependable operation and long life with minimum service requirements, and 4—a construction providing controlled and efficient conveying.

Under the usual conditions of cooling during the handling, the construction selected to withstand the initial maximum temperatures does not necessarily involve using alloys, as excellent results can be achieved with normal carbon steels and cast irons, when they are properly applied and proportioned.

The earliest and simplest type of conveyor for handling very hot materials is the cast steel drag chain conveyor, still widely used for handling hot cement clinker, as illustrated by Figs. 1 and 2. Because of the rugged and generous proportions of the chain link design, low carbon steels are entirely suitable for the links. The pins, however, must be alloy steel. The simple, rugged construction of this type of conveyor makes it readily capable of withstanding high initial temperatures, even though the chain is operating buried in the material.

The drag-chain type of conveyor has advantages and limitations. Although the efficiency of the heat transfer is relatively poor, the life of the conveyor is reasonably long, and because of its crude simplicity it does not require much servicing. However, as a conveyor, it is limited in capacity, and largely limited to horizontal runs. Furthermore, because of the crude design, heavy weight, and the chain operating at the temperature of the material, greatly reducing permissible operating chain pulls, this type of conveyor is limited to relatively short centers.

Another type of conveyor that has been used for very hot materials is the cast pan conveyor. Because of its very generous proportions the cast pan, which is made of either cast iron or malleable iron, can withstand initial maximum temperatures. It also provides efficient heat transfer for cooling. Further, it is on efficient conveyor construction, which can be used for inclines. Because the chain employs rolling friction instead of sliding friction, and is not in the maximum temperature zone, much longer centers are possible.

It is this type of conveyor that is frequently used in the casting of various metal pigs, pig iron, and aluminum; it is obvious, therefore, that very high initial temperatures are being handled. With this kind of conveyor the return run is frequently sprayed with water to accelerate heat transfer. The build-up of residual heat in the very heavy cast pans is thus overcome.

The outboard roller steel pan conveyor is an improved pan conveyor which provides high rates of heat transfer and substitutes formed steel pans for the heavy cast pans. It is a very efficient conveying medium. The details of this particular construction are clearly shown in Fig. 3. An early application of this type of conveyor is shown in Fig. 4. In this case the conveyor units are handling roasted phosphate rock at average temperatures of 1000° to 1500°F, and frequent maximum temperatures as high as 1900°F. Several widths are used. The capacity of the unit at a speed of 50 fpm is approximately 30 tph per inch of width at peak loadings, average capacity being about 1/3 of peak loading.

The assembled conveyor is shown in Fig. 5, with views of both the top and the underside to show all the construction details. In particular, the following general design principles were carried out in this construction:

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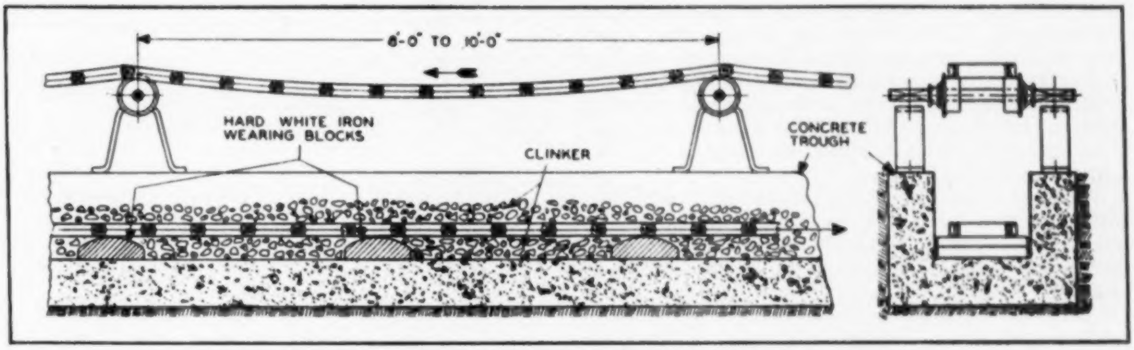


Fig. 1—Economical construction of a ground-level trough for hot or cold cement clinker.

1—The capacity of the conveyor, that is, the size of the pan and the speed, together with the weights of the steels used, was designed so that the mass of the carrying pan is considerably greater than the mass of the live load of hot material. This ratio should be approximately 2 or 3 to 1 for peak load conditions. The maximum initial temperatures are thus easily handled and any localization of intense heat is no problem.

2—The shape of the pans provides maximum surface area for efficient cooling.

3—The operating speed is low, approximately 50 fpm, permitting complete cooling on the return run and also greatly reducing the rate of wear.

4—The chain and carrying rollers are insulated from the heat zone.

5—The wear is largely confined to heavy, carrying, outboard rollers, on sleeve-type bushings, both made of heat-treated white iron, extremely hard and long-wearing.

6—The function of the chain is solely to pull the load, and the through-rods connecting the two strands of chain, visible in the view of the bottom side of the conveyor, further prolong chain life by providing exceptional rigidity.

7—The unique outboard roller construction permits easy servicing without the need of any disassembly of the chain or conveyor. Individual servicing or replacement of rollers, bushings, or even pans, can be done without disturbing the chain or the remainder of the conveyor.

8—The lubrication requirement is simple. Graphite, applied in a suitable vehicle such as kerosene, which quickly evaporates, is all that is required. Anti-friction bearings are not practical in the outboard rollers because the seals are difficult to install

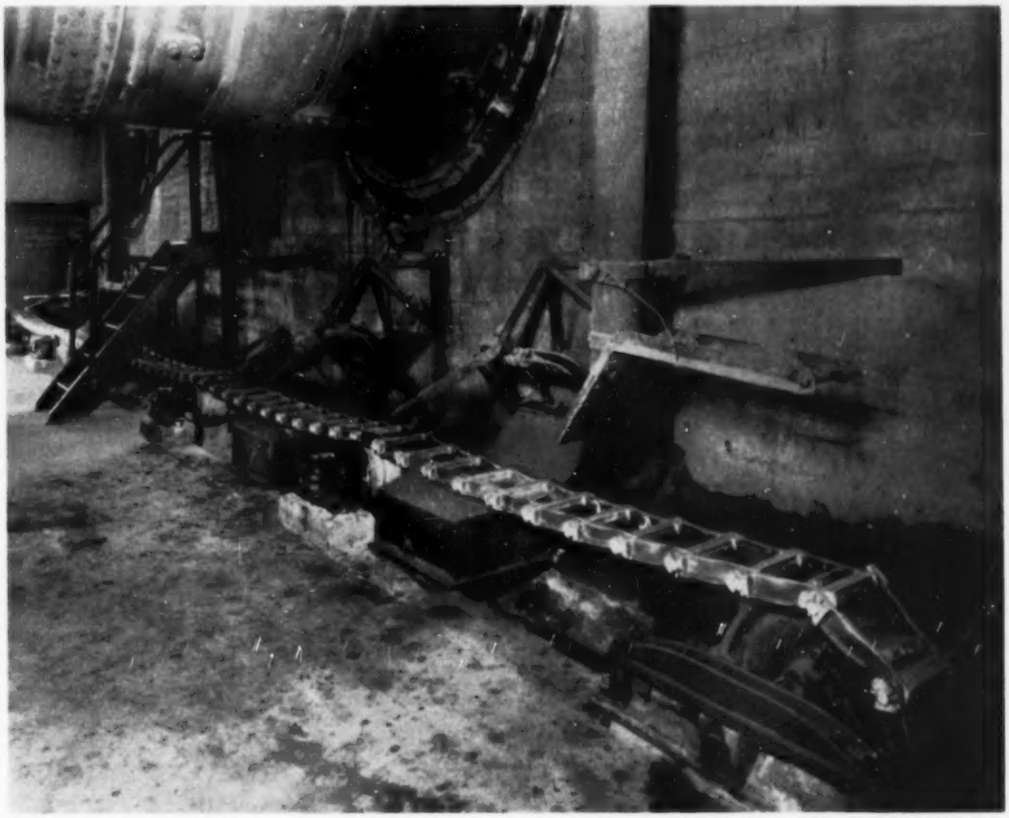


Fig. 2—Hot clinker and clinker dust are transported by the Rex drag conveyor illustrated. No. 123 cast steel drag chain belt is used.

and maintain, and, further, it is difficult to retain conventional lubricants in the anti-friction bearings under the heat conditions prevailing.

9—The relatively low power requirement, resulting from the use of the large diameter carrying rollers, and the shape of the pans, suitable for handling up steel inclines, make this construction an efficient conveyor medium.

A study of the foregoing principles reveals why other types of conveyors have not proved successful for the handling of materials at elevated temperatures. With steel conveyor belts, either carbon or stainless steel, the ratio of the mass of hot material to the mass of the belt is high, intensifying the effect of the localization of heat. Moreover, because the belt cannot be loaded full width out to the edges, the temperature of the belt is not uniform across its width, setting up severe expansion problems within the belt, causing buckling at the center and subsequent cracking as it goes around the terminal pulleys.

Vibrating conveyors have also proved unsatisfactory because of their poor heat transfer. The shape of the trough provides only nominal radiation area, and there is no return run for further cooling. As a result, the heat retention causes warping and distortion, which prevents the unit from conveying.

Leakproof Bucket Elevators

Where the vertical elevating of hot bulk materials is required by plant space limitations, bucket elevators can be used equally effectively if the same general design considerations are followed. Fig. 8 illustrates a special construction of slow speed, continuous bucket elevator that is in successful use handling calcined bauxite, highly abrasive, at initial temperatures of 1200°F.

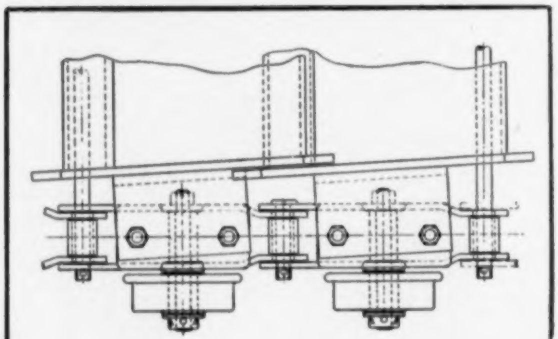
The detailed cross section of the construction shows the entirely leak-proof design of the bucket, with overlapping construction. This feature also makes possible very slow operating speeds. Normal construction of continuous-type bucket elevators does not provide for overlapping buckets, and small gaps open between buckets going around the terminals. A bucket speed of approximately 125 fpm is therefore required to throw material across these gaps to prevent spillage and back-legging. With the complete overlapping construction of Fig. 6, both on the bucket sides and on the bucket back and front, speeds of 60 fpm or slower are practical.

This bucket elevator design carries out the following general principles, which are parallel to the considerations for the pan conveyor, previously described, for the elevating of hot materials:

1—The capacity of the elevator, that is, the size of the bucket and speed, and the weight of the steels used provide a mass of the bucket greater than the mass of the live load being carried. This should be approximately a minimum of 3 or 4 to 1 for peak loading conditions. Maximum initial temperatures

Table I. Chains to Use at High Temperatures

Type of Chain	Maximum Temperature, °F	Heat Colors	Remarks
A.S.A. standard steel roller	350		
Extra clearance roller chains Replacement series roller chains	500		"Nitroalloy" bushings for best wearing qualities
Stainless steel (18-8) block or roller chains	800		Non-Corrosive as well as heat-resistant
	900	Faint red visible in twilight	
Monel metal block, stud or leaf chains	1000	Red visible in daylight	Nitrided pins for best wearing qualities
Cast steel chains (rollerless)	1050	Blood red	Low carbon steel links, alloy steel pins
Stainless steel (18-8) stud or leaf chains	1600	Bright red	
	1650	Salmon	Scaling temper, 18-8 stainless
Inconel nickel-chromium alloy (80-14) stud or leaf chains	2100		A wrought material extremely scale-resistant
Cast nichrome V 20-80	2100	Light yellow to white	Detachable or pintle type
Cast chrome A 20-80	2100		Detachable or pintle type



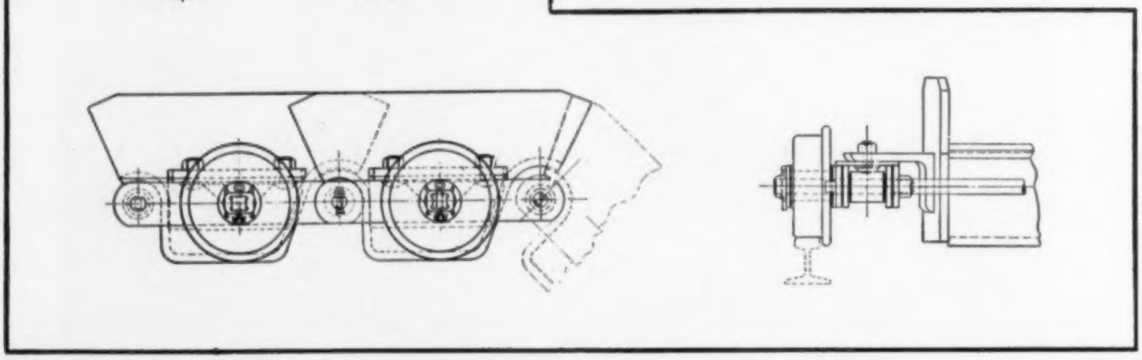


Fig. 3—Style C apron conveyor. Upper left, plan view. Lower left, side view. Lower right, end view.

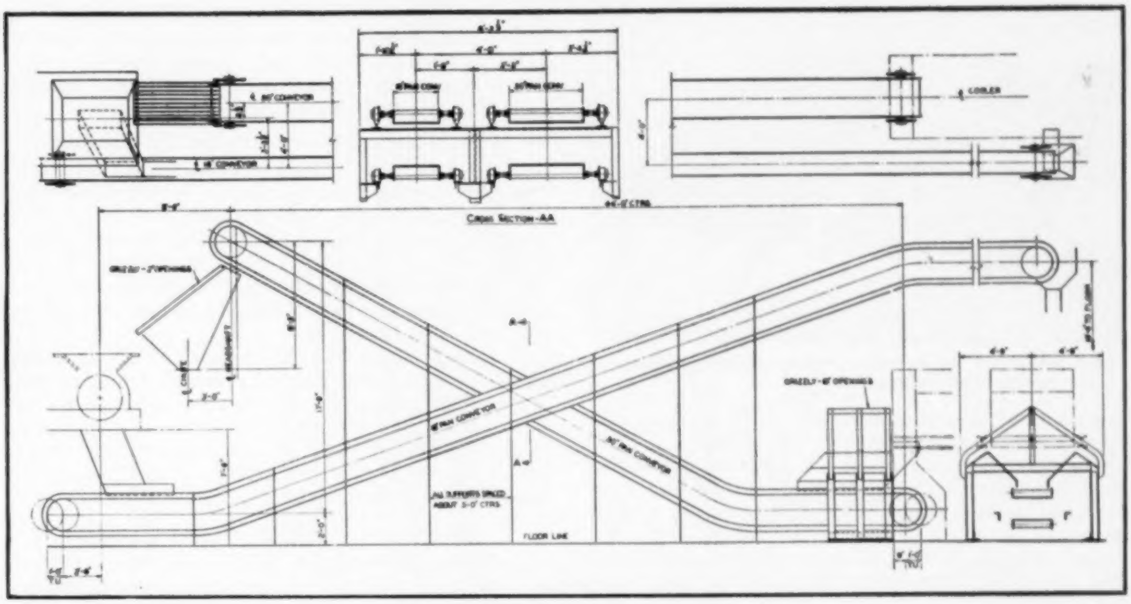


Fig. 4—Phosphate rock pan conveyors.

are easily handled without the necessity of special provisions.

2—The design and shape of the buckets, with the extended sides, bottom and back, provide maximum surface area for efficient cooling.

3—The operating speed is low, approximately 50 fpm, permitting efficient cooling on the return run and greatly reducing wear.

4—The chain is at least partially insulated from the high-heat zone.

5—The venting of the elevator casing helps to dissipate the heat.

6—The unique bucket design, which is entirely leakproof, keeps the chain completely clean, providing for longer wear and less servicing.

7—The design is a very efficient conveying medium, and in fact can be used as an accurate volumetric feeder.

A study of the foregoing shows why the attempted use of the en masse type of conveyor has been unsuccessful for the elevating of hot materials. With the en masse type of conveyor, the chain is completely buried in the material and therefore remains at maximum temperature. The surface area is only nominal, and the ratio of the mass of the hot material to the conveyor is much too high for efficient cooling. The cooling on the return run is also poor.

Further additional general considerations of both the constructions described are in order. It is obvious that normal conveyor capacity ratings and ratios of live to dead loads are discarded. Providing efficient heat transfer upsets usual relationships.

A higher ratio of mass of carrying medium to load is desirable for the bucket elevator than for the apron conveyor. This is true because the closer confinement of the elevator casing makes it harder to

Table II. Temperature Factors for Maximum Allowable Design Stresses

	Temperature, °F	TYPE OF CHAIN						
		A. S. A. Standard Steel Roller	Replacement Series Roller	Rolled Monel Metal	Cast Steel Chains	Cast High Manganese Steel	Wrought Stainless 18-8	Super Alloys
MODERATE TEMPERATURES	Room 70	100 pct	100 pct	100 pct	100 pct	100 pct	100 pct	100 pct
	200	100	100	95	100	89	86	100
	300	100	100	93	100	84	79	100
	350	100	100	93	100	81	76.5	100
	400		100	93	100	80	76.5	100
	500		100	92	100	76	76.5	100
	600			85	100	74	76.5	100
	700			70.5	100	74	76.5	100
	800			60	100	74	73	100
	850			54	92	74	71.5	100
	900			50.5	86	74	70	100
	950			48.5	76	74	67.5	100
	1000			46.5	64	74	63.5	100
	1050				56	74	61.5	86
HIGH TEMPERATURES	1100						56	76.5
	1200						48	59.5
	1300						37.7	47.5
	1400						25.7	37
	1500						18.6	30
	1600						15.8	25
	1700							21.5
	1800							17
	1900							12
	2000							9.5

Above data has been computed on the basis of stress causing creep rate of 1 pct elongation in 10,000 hr.

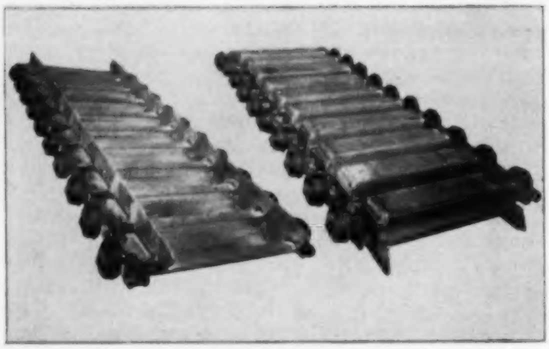


Fig. 5—Views of the assembled conveyor, top and underside, show the construction details.

remove the heat and because the chain is not so well protected from the maximum heat zone.

The slow operating speed increases the life of the working parts far more than would normally be expected. Rather than a straight line function, with the increase in life directly proportional to the decrease in speed, the relationship is a geometric one. This is comparable to increase in life in relation to the difference of the squares of the speeds. Slowing down the operation of the units therefore pays handsome dividends in service life.

In the design of wearing parts, conservative unit live-bearing pressures should be used, probably only 75 pct of normal ratings. While the temperatures of the working parts are not in the critical ranges, nevertheless the temperatures are above normal, effective lubrication is largely non-existant, and a high ratio of dead load to live load exists.

The selection of terminal equipment must likewise be tailored to the operating conditions. Such provisions as expansion joints for enclosures, gravity takeup arrangements, and bronze-bushed pillow block equipment, rather than anti-friction bearing or babbitted, are obvious necessities.

Material at Sustained Maximum Temperatures

Some processes demand sustained operation at the high operating temperatures. Where those conditions must be met, then the selection of the alloy materials must withstand the full effect of the temperatures over prolonged periods of time. Briefly, the problem is one of providing for creep, combating oxidation, and combating loss of strength as it affects working load capacities.

Various manganese, nickel, and chromium alloys can be used for operation at elevated temperatures. Based upon extensive study and experience on the part of the Baldwin-Duckworth Division of Chain Belt Co., Tables I and II present, in convenient form, the basis for the proper selection of alloys to be used at various temperature ranges.

Special Alloy Continuous Bucket Elevators

Cutstanding examples of successful construction for sustained operation at high temperatures are the bucket elevators, used for handling the hot catalyst in the Thermofor Catalytic Cracking Refining Process, which were developed by Jeffrey Manufacturing Co.

Fig. 7 shows the flowsheet of the refining process. These bucket elevators must operate continuously 24 hr a day, 7 days a week, for a minimum of 9000 to 10,000 operating hr before any reconditioning, all the while handling highly abrasive material at 1000°F. The elevator casings must be gas-tight to insure operation in a completely inert atmosphere. Moreover, a number of these bucket elevators are

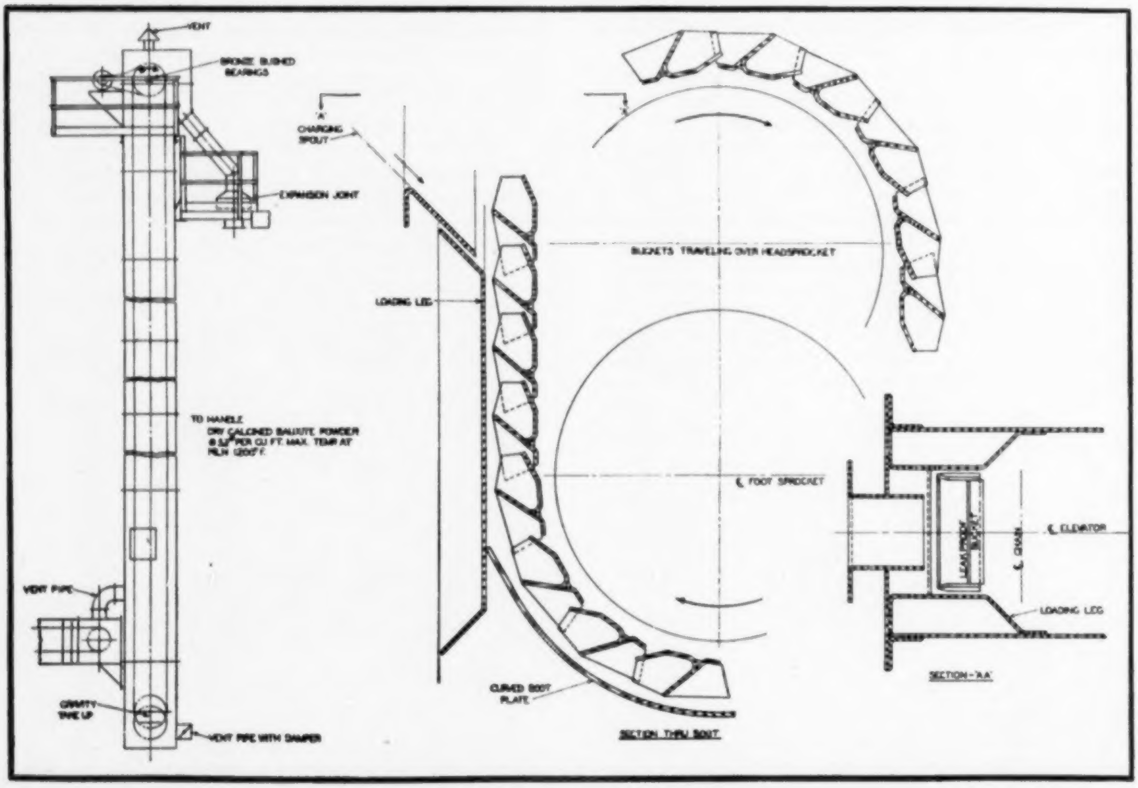


Fig. 6—Design of the leakproof bucket elevator.

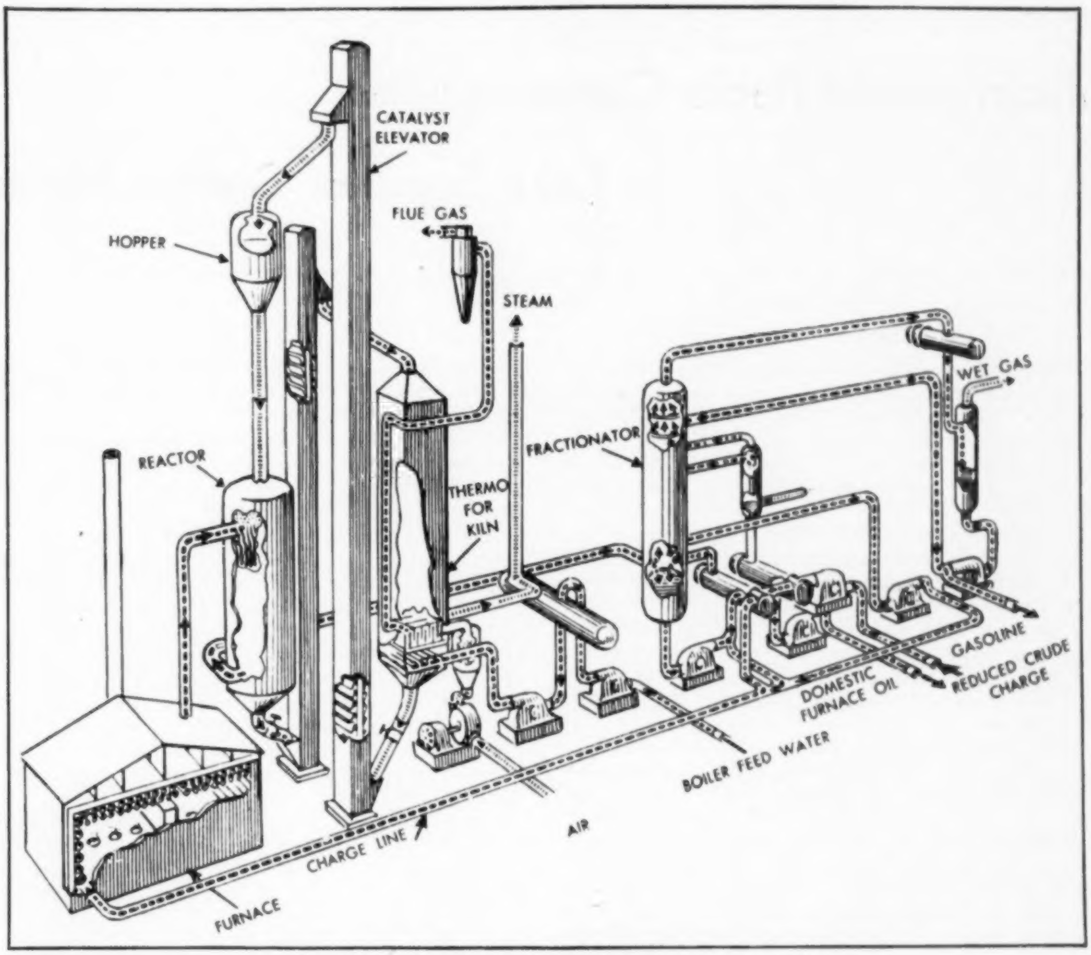


Fig. 7—General process flow diagram for TCC plant on liquid charge.

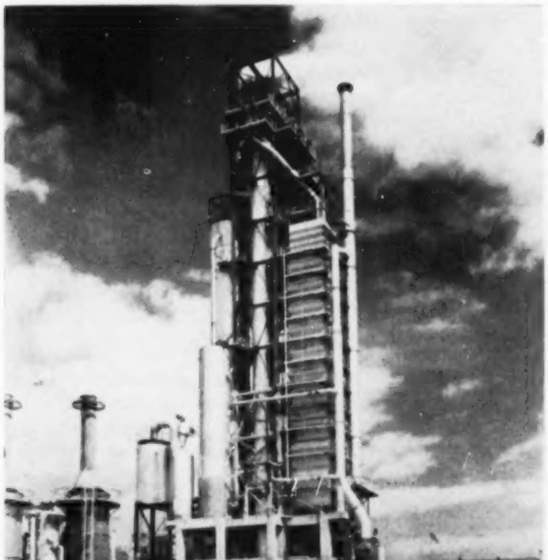


Fig. 8—View of the entire cracking unit. The bucket elevator is located within the cylindrical casing.

in operation handling 100 to 200 tph of 50 lb per cu ft material with centers of 200 ft, in itself a real design problem. Super units will soon go into operation handling 500 tph with a 300-ft lift.

The special chain was designed for proper strength, hardness, and creep rate. One detail of construction illustrates what can be done. The bushings are made of special heat-treated Ni-Hard castings, ground to size, and shrunk-fitted into the chain sidebars. At room temperature the hardness of these bushings is 600 Brinell and at operating temperatures 477 Brinell. The service life of the special chain has approached as much as 18,000 hr before reconditioning has become necessary.

The elevator casing is cylindrical, and as seen in Fig. 8, which shows the entire cracking unit, the bucket elevator is located within the structural steel work and would scarcely be recognized as a bucket elevator were that fact not previously known.

Acknowledgments

Acknowledgment is hereby given to the Engineering Department of the Baldwin-Duckworth Division at Chain Belt Co. for Tables I and II, to A. W. Lemmon, Consultant Sales Engineer of the Jeffery Manufacturing Co., Columbus, Ohio, for the information given on the T. C. C. bucket elevators, and to D. L. Schott, Chain Belt Co., Milwaukee, Wis., for criticism of the heat transfer phases presented.

Underground Radio Communication In Lake Superior District Mines

by E. W. Felegy

THE need for improved mine communication to increase efficiency and to insure greater safety has long been recognized. General and unrestricted communication between all points underground, and between the surface and all points underground, is probably the least advanced phase of the mining industry.

An ideal system of mine communication must require no fixed wire installations. The equipment must be small, lightweight, and readily portable, and the power requirements low. A system that can be used not only under normal circumstances but also in an emergency, when the continuity of wires, tracks, and pipelines may be disrupted, must function independently of any aid furnished by standard installations.

Radio communication offers possibilities of meeting all the requirements necessary for an ideal communication system in underground mines. Transmission of signals must be achieved through one or both of two mediums, through the air in mine openings or through the strata. The results or lack of results obtained by early investigators showed conclusively that radio communication by space transmission cannot be accomplished effectively beyond line-of-sight distances in underground passageways. A radio system underground therefore must depend solely upon transmission through soil and strata.

The application of radio to underground mine communication was investigated by many individuals and agencies at different times in the last several decades, but little success was achieved before World War II.[2-6, 8, 9, 11-16, 18, 19, 21] The results of experiments during the war, and further knowledge gained in experiments with vastly improved communication methods and equipment after the war[1, 7, 10, 17, 20, 22] provided the background for additional research in radio communication in underground mines.

During 1950 to 1952 the University of Minnesota sponsored an investigation to determine the possibility of developing a system of radio communication universally applicable in underground metal mines in the Lake Superior district. The possibility of using radio equipment to determine the imminence of rock bursts in deep copper mines in that district also was investigated. The investigation supplemented previous and concurrent emergency mine communication studies of the U. S. Bureau of Mines. Testing equipment and laboratory facilities maintained by the Bureau of Mines at Duluth, Minnesota, were used in the research program, which was conducted as a mining engineering graduate research problem by the present writer under the direction of T. L. Joseph and E. P. Pfleider.

The radio units used in the research program were designed and built to specification solely to conduct tests of radio communication in mines. Two identical units were used in all tests.

Each unit contained a transmitter section, a receiver section, and a power-supply section, mounted on a single chassis. The entire unit was enclosed in a single 10x12x18-in. metal case provided with a leather-strap handle for carrying purposes. The front of the case was hinged to open upward and provide easy access to the single control panel on which all controls were mounted. Storage batteries supplied the operating power for all tests. Standard 6-v automobile batteries were utilized to provide adequate capacity to conduct tests for a full day without exhausting the battery.

A frequency range from 30 to 200 kc was covered in eight pre-fixed steps on each unit. The carrier frequencies were crystal-controlled and amplitude-modulated. The receiver employed an essentially standard superheterodyne circuit and was sufficiently sensitive to detect signal strengths of 5 micro v. A heterodyne circuit was employed in the transmitter to obtain the low-carrier frequencies used in the units. Power output of the transmitter, usually less than 2 w, rarely exceeded 3 w in any test.

Tests were conducted in mines on the Vermillion iron range in Minnesota, the Gogebic iron range in Wisconsin, the Menominee and Marquette iron ranges in Michigan, and a copper mine in the upper Michigan peninsula. All tests were conducted when the mines were operating normally, and usual mining, maintenance, and transportation activities were in progress, so that any interference caused by normal production activities could be evaluated during the tests. Tests were made between different points underground in each mine, and between underground and surface points at some mines. Test readings obtained at any one mine were calibrated in the laboratory before another series of tests were begun at the next mine. The transmitter and receiver were separated by one or more levels in each test, and generally there was no other means of communication between test points.

Two 100-ft lengths of rubber-covered wire were used for antenna wires on each unit in both transmission and reception. The ends of the wires were connected to ground points in one of several methods, depending upon physical conditions at each test site. The wires were clipped to metal rods about 200 ft apart in the back, side, or bottom of the mine opening where the character of the rock permitted driving rods. Both wires were clipped to points about

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Table I. Summary of Test Results at Montreal Mine

Distance in Feet	Type of Strata	Wire Aid	Signal Strength	Noise	Remarks
270	Ore	Yes	High	High	
375	Ore	Yes	High	High	
260	Greenstone	No	High	Negligible	
504	Greenstone	No	High	Negligible	
525	Greenstone	No	High	Negligible	
1085	Greenstone	No	Medium	Medium	
1135	Greenstone	No	Medium	Medium	
Over 1500	Greenstone, quartz slate	No	None	Excessively high	Failure to communicate possibly due to noise
1330	Greenstone, iron formation	No	None	Excessively high	Failure to communicate probably due to noise
1045	Greenstone, iron formation with faults and dikes	No	None	Excessively high	Failure to communicate probably due to noise
970	Greenstone, quartz slate, and soil	No	Medium	High	Local broadcast station interfered on surface; noise low underground

200 ft apart on the track or on pipelines in other tests, or one wire was clipped to the track or pipeline and one to a ground rod. Antenna wires of a radio unit on the surface for a test at a mine always were connected to metal rods about 200 ft apart in the ground.

To eliminate transmission of signals by wire circuits one or both radio units were set up, wherever possible, at tests sites without wire installations. It was also possible in a few instances to utilize sites having no pipelines and track. Despite the precautions observed in selecting sites, however, some individual results showed that wire circuits not in proximity to the radio units did aid in transmitting signals.

Frequency-response curves, obtained by plotting received signal strengths against carrier frequencies for each test, indicated whether communication was achieved through the strata or by means of wire circuits. Eve suggested the validity of such curves[5, 6] after making tests in the Mount Royal tunnel in Canada and the Mammoth Cave in Kentucky. His conclusions were reaffirmed, most recently by Felegy and others,[1, 7] after tests conducted in various mining regions in the United States.

A frequency-response curve shows maximum signal strengths received at the lowest frequency tested, and constantly decreasing signal strengths as the frequency increases when communication is achieved through the strata, see Curve a, Fig. 1. The general trend of a frequency-response curve is reversed, so that received signal strengths increase as the frequency increases where communication is achieved by wire aid; one or more peaks may occur in the curve between the lowest and highest frequencies, Curve b, Fig. 1. The difference in frequency-response curves usually is easily distinguishable. When the curves obtained in individual tests in this investigation indicated that communication was not achieved solely through the strata, those tests were not considered in determining the feasibility of radio communication in underground mines.

Tests at each mine were concluded when the maximum distance through which communication was possible was determined at that mine, or when no other suitable test sites were available, or, as at one mine, when it was determined that communication through the strata was not possible.

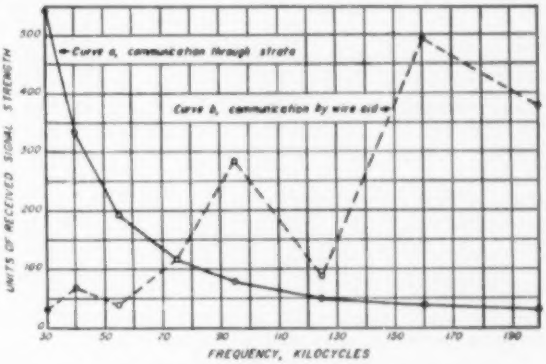

Fig. 1—Typical frequency response curves.

Fig. 2 is a diagrammatic section showing sites and relative positions of radio units in tests conducted at the Montreal mine, Montreal Mining Co., on the Gogebic iron range in Wisconsin. Table I is a summary of test results obtained at that mine.

Satisfactory two-way voice communication was achieved through a maximum distance of 1135 ft between underground points in the Montreal mine. Noise interference on the radio units was intense where the units were set up in or near operating sections of the mine. Satisfactory grounding of elec-

Table II. Summary of Test Results at Pioneer Mine

Distance in Feet	Type of Strata	Wire Aid	Signal Strength	Noise	Remarks
180	Greenstone	Possibly	High	Low	
340	Greenstone	No	High	Low	
775	Greenstone, iron formation	No	Medium	Medium	
1285	Greenstone, iron formation	Possibly	Low	High	
1000	Ore, iron formation, area faulted	No	None	High	Failure to communicate probably due to faults
1165	Caved jasper and soil	No	High	Low	
1330	Caved and solid jasper, and soil	No	Medium	Low	
1496	Caved and solid jasper, and soil	No	Low	Low	Maximum limit; insufficient signal strength to increase distance

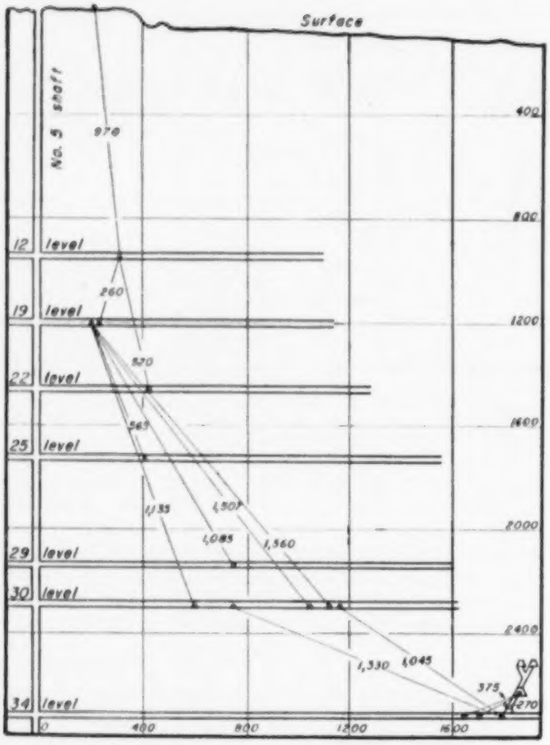

Fig. 2—Diagrammatic section showing test sites and distances, Montreal mine.

trical equipment presents a difficult problem in the Montreal mine, and it appeared that the excessive noise interference in the radio receivers was related to the grounding problems. The distance through which communication was possible between underground points appeared to be limited by noise interference rather than by lack of signal strength.

Satisfactory communication was achieved through 970 ft of soil and strata between a point on the surface and a point underground at the Montreal mine. A greater distance was possible but was not attempted because interference of the local broadcast station on the surface made two-way communication extremely difficult. Reception underground in that test was loud and clear.

Table II is a summary of results obtained in tests between underground points and between underground and surface points at the Pioneer mine, Oliver Iron Mining Division, U. S. Steel Corp., on the Vermillion iron range in Minnesota. Communication was achieved satisfactorily through 775 ft of strata between underground points. Communication was achieved through a distance of 1285 ft between underground points in one test, but some aid may have been obtained from wire circuits in that test. Satisfactory communication was obtained through 1496 ft of soil and strata between a point on the surface and a point underground, and the low signal strengths received indicated that the distance probably could not be increased. Communication was not achieved between a point in the Pioneer mine and a point about 1000 ft away in the adjoining Zenith mine. Noise interference was excessive in that test, and faults were known to exist in the pertinent area. The reason for failure to communicate could not be determined definitely, and it was not possible to conduct tests through shorter distances between test sites in the two mines.

Communication could not be achieved satisfactorily through the strata alone at the James mine, Pickands Mather & Co., on the Menominee iron range in Michigan. Occasionally, in tests through distances not exceeding 400 ft the carrier signal was identified but no voice was heard. On fewer occasions voice was distinguishable and some words were heard on one or the other of the receivers, but two-way communication never was possible. Failure to achieve radio communication through the strata at the James mine can be attributed to peculiar strata characteristics that also interfere with geophysical investigations on the Menominee range.

Table III is a summary of test results at the Cliffs Shaft mine, the Cleveland-Cliffs Iron Co., on the Marquette iron range in Michigan. Satisfactory two-way communication was achieved through 475 ft of strata between underground points. Received signals were loud and clear, and communication could have been achieved through much greater distances, but suitable test sites devoid of wire installations were not available. Maximum distance through which communication was possible at the Cliffs Shaft mine was computed to be 1200 to 1500 ft, based on rates of attenuation determined in tests at that mine.

Table IV is a summary of test results at the Ahmeek No. 3 copper mine, Calumet and Hecla Inc., near Calumet, Michigan. Satisfactory communication was achieved through 490 ft of strata between underground points at that mine, and the maximum distance through which communication was possible was computed to be from 1250 to 1750 ft.

Frequency-response curves, made after laboratory calibration of results obtained in tests conducted in an attempt to predict rock bursts in the Ahmeek No. 3 mine, indicated some difference in results obtained in rockburst and in non-rockburst areas. Those differences, however, were not immediately discernible during the progress of the tests in the mine, even though one radio had been set up nearly 7 hr at the exact site where a rock burst occurred within 30 min after the tests were concluded.

Conclusions

1—Without dependence on aid furnished by wire circuits in the mines, voice communication by radio

Table III. Summary of Test Results at Cliffs Shaft Mine

Distance in Feet	Type of Strata	Wire Aid	Signal Strength	Noise	Remarks
240	Footwall iron formation	No	High	Low	
350	Ore, iron formation	No	High	Low	
215	Ore	No	High	Low	
475	Ore	No	High	Low	Computed maximum distance 1200 to 1500 ft
317	Iron formation	No	High	Low	Computed maximum distance 1500 feet

Table IV. Summary of Test Results at Ahmeek No. 3 Copper Mine

Distance in Feet	Type of Strata	Wire Aid	Signal Strength	Noise	Remarks
200	Amygdaloidal basalt	No	High	Low	Computed maximum distance from results of this series of tests 1250 to 1750 ft
490	Amygdaloidal basalt	No	Medium	Low	
418	Amygdaloidal basalt	No	Medium	Low	Intervening mohawkite vein caused differences in signal strengths in this series of tests
422	Amygdaloidal basalt and mohawkite vein	No	Low	Low	
254	Amygdaloidal basalt	No	High	Low	Non-rockburst area
246	Amygdaloidal basalt	No	High	Low	Rockburst area; frequency response differs from above after calibration

between all points underground or between the surface and all points underground is not feasible in metal mines in the Lake Superior district by means of currently known equipment and techniques.

2—Radio communication is possible over distances of several miles between points in proximity to wire circuits underground. Pipelines and rails near transmitting and receiving points, in the absence of wire circuits, generally do not greatly increase the range of communication.

3—Best results in communication through the strata were obtained at the lowest frequencies tested. It appears that future research in the development of a system of radio communication universally applicable in underground mines should be concentrated on the use of very low radio frequencies, ranging from 20 to 50 kc.

4—The type of rock through which signals were transmitted generally did not appear to be a controlling factor in determining the success or failure of communication, except on the Menominee iron range. No appreciable difference was observed between results obtained by transmitting through greenstone or other rock and results obtained by transmitting through ore.

5—Fault zones between transmitting and receiving points appeared to interfere with communication, and in some tests, signal strengths appeared to be diminished by passage through interfaces of contiguous dissimilar strata.

6—Noise interference and insufficient power output were the two principal factors limiting the distance through which communication was possible.

7—The communication equipment was not adaptable to on-the-spot prediction of rock bursts in a deep copper mine.

8—Additional improvements in equipment and techniques should justify future research in underground radio communication; a system of radio communication universally applicable in underground mines then may be proved feasible.

Acknowledgments

Sincere appreciation is expressed to numerous officials and other personnel of Calumet and Hecla Inc., Cleveland-Cliffs Iron Co., Montreal Mining Co., the Oliver Iron Mining Division of U. S. Steel Corp., and Pickands Mather & Co. for their wholehearted courtesy and cooperation in making possible the experiments at mines of their companies.

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Quantitative Petrographic Composition Of Three Alabama Coals

by Reynold Q. Shotts

Nitric acid oxidation rate analyses of three coals, previously studied microscopically by the Bureau of Mines, revealed three components. Relative quantities agree with those found for the four components given by the Bureau and results are consistent with current ideas of coal constitution. Possible multi-component composition for *bright* coal and a reactivity-rank relation are suggested.

THE physically dissimilar components of bituminous coals often are easily recognized megascopically. Under the microscope, reflected light or light transmitted through thin sections reveals the presence of the different components, even when these are intimately mixed. Optical methods for the quantitative estimation of the relative abundance of the various components, both by means of thin sections and by particle count, have been fully described.[1, 2]

It has long been recognized that there are chemical and physical differences between the various petrographic components of bituminous coals, although analytical differences usually are small.[3, 4] Only in the case of fusain have chemical differences been used for quantitative determination of a component. C. C. Hsiao and associates, at the Mineral Industries Experiment Station of the Pennsylvania State College, have described a method of analysis which is based upon the differences in the rate of nitric acid (8N) oxidation, fusain, and the other components of coal.[5, 6] The reproducibility of their method and its applicability in checking microscopic determinations of fusain content have been supported by several independent investigations.[7, 8]

The writer has proposed the use of differences in oxidizability for the estimation of other components.[9, 10] The results of the oxidation of whole coals and of float-and-sink fractions of coals were reported. In most cases the plots of the logarithms of the percent dry, non-fusain, organic residue from oxidation, against time, revealed the presence of at least two distinct components. Both components appeared to oxidize according to a first order law, but the reaction constants for the components were distinctly different. One or more of the *dull* density fractions were found to contain but one component, and some of the lower rank coals oxidized in such a way as to suggest the presence of three components.

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Discussion on this paper, TP 3526F, may be sent (2 copies) to AIME before July 31, 1953. Manuscript, Oct. 25, 1951. Revised Feb. 23, 1953.

A suitable way to check the identity and significance of the components delineated by oxidation would be to analyze a sample of coal both by the nitric acid oxidation procedure and by a microscopic method. The writer was wholly unfamiliar with either of the microscopic techniques commonly used, and to make such a comparison it was necessary to rely upon microscopic analyses made by someone else. It is hoped that some laboratory which is equipped to make both types of analyses will some day make them upon identical samples.

During the past 20 years, four Alabama coals have been analyzed petrographically and the results published by the United States Bureau of Mines. They are: 1—Flat Top mine, Mary Lee bed; 2—Empire mine, Black Creek bed; 3—Wylam No. 8 mine, Pratt bed, all in the Warrior field; and 4—Soot Creek mine, Fairview bed, in the Coosa field.[11-14] Of these, only the Flat Top mine is still operating. Because of the closing of these mines, it first appeared necessary to rely upon the indirect and unsatisfactory procedure of sampling the beds in other mines located as near to the closed mines as possible. Upon investigation, however, it was found that the Bureau of Mines still had, in storage, the very same samples which had been used in the published petrographic studies. The Bureau very generously furnished about 2000 g each of the Pratt, Mary Lee, and Fairview bed coals, largely lumps but with some fines. The blocks of coal, when received, still were covered by the paraffin coating which had been placed on the polished surface, in the case of the Mary Lee coal almost twenty years ago.

Procedure

The procedure for oxidizing the coal sample and removing the alkali-soluble humic acid has been described.[5, 9] In the present study, oxidation periods of 1/6, 1/3, 1/2, 3/4, 1, 2, 3, and 4 hr were used. All oxidations were made in triplicate. After the paraffin had been removed in boiling water and the coal washed carefully with cold benzene, the entire sample of approximately 2000 g, obtained from the Bureau of Mines, was crushed to pass a No. 4 sieve. About 200 g of this material was pulverized to pass

Table I. Proximate Analyses and Free Swelling Indexes of Coals Studied

Mine and Bed	Ash(1), Pct	Volatile(1) Matter, Pct	Fixed(1) Carbon, Pct	Sulphur(1), Pct	Heating Value Btu/Lb	Unit Fixed Carbon, Pct	Unit Heating Value Btu/Lb	Free-Swelling Index
Wylam No. 8, Pratt Bed	3.0	30.5	66.5	0.6	14,700	68.9	15,220	7
Flat Top, Mary Lee Bed	9.9	27.6	62.5	0.6	13,660	70.1	15,310	8
Soot Creek, Fairview Bed	7.1	27.6	65.3	2.2	13,850	71.3	15,510	7½

(1) Dry basis.

a No. 200 sieve and stored in bottles. As oxidations were made, a few grams were removed from the storage bottle, placed in a weighing bottle, and dried. All analyses were run using dry coal. Since the petrographic sections given in the reports were uniform, it is likely that the blocks of coal furnished by the Bureau were genuinely representative of the entire bed section.

Chemical and Physical Properties of the Coals

Analyses and free swelling indexes of the three coals are shown in Table I. Heating values and free swelling indexes undoubtedly have been reduced by the long storage period, although the present values indicate that only small changes have occurred.

The three coals are almost identical in rank as shown by the values for dry fixed carbon free of mineral matter. Pratt coal falls very near the border line between medium-volatile bituminous and high-volatile A bituminous coals. The other two coals are just inside the medium-volatile bituminous group. The non-fusain portion of Fairview coal may not be of quite the rank indicated because of the relatively high fusain content. The presence of considerable fusain in this coal probably reduces its free swelling index slightly.

Results of Oxidations

Fig. 1 shows the logarithm of the percent moisture and ash-free residue, minus the fusain residue, plotted against the time. Fusain residues were read from Fig. 2. It is evident that for all three coals oxidation was rapid during the first 10 min. A straight line has been drawn connecting the non-fusain organic matter at zero time with that remaining at 1/6 hr, indicating that the full 10-min period was required for the oxidation of the more reactive portion of the coal and that the rate was uniform for the period. This may not have been true, but because of the absence of shorter oxidation periods it was necessary to make this assumption. A reaction rate constant based upon this assumed straight line is not an accurate value but should represent an approximate average for the first 10 min.

It will be observed that only in the case of the Mary Lee coal did the percent of residue, after 2-hr oxidation, fall near the line drawn through the other points. This is not surprising, for the non-fusain residue, after such prolonged oxidation, was very small for all the coals. Slight analytical errors could result in sizable displacement from the true value.

Fig. 2 shows the longer oxidation periods plotted against time, on rectangular coordinates. Extrapolation to zero time of the line joining percents residue after 3 and 4-hr oxidations gives the percent of fusain in the sample.[5]

Comparison with Microscopic Analyses

Table II shows the composition of the three coals as published by the United States Bureau of Mines and as determined by oxidation with nitric acid. The table also shows the specific reaction constants for the *bright*, *dull*, and fusain components.

The symbols used in Tables II to IV are the same ones used previously by the writer and others.[6, 9] The symbols C_{c-1}, C_{c-2}, C_{c-3}, C_f refer to the percent of fusain and of other coal components, in descending order of their brightness, in the original dry, ash-free coal; K_{c-1}, K_{c-2}, K_{c-3}, K_f are the corresponding specific reaction constants for the same components, in units of percent of material oxidized per hr.

In the case of Pratt and Mary Lee coals, the percent of dull coal, fusain-free basis, was larger than that of the Bureau of Mines' opaque attritus and less than the sum of the opaque and the translucent attritus. For Fairview coal, the dull component was equal to the sum of the translucent and the opaque attritus. The percentages of fusain, as determined by the two methods, did not check exactly, although it is probable that the values shown differ little, if any, from those to be expected for duplicate samples of the same coal as determined by either method. The samples sent by the Bureau of Mines were largely of lump coal, so that the fusain content ob-

Table II. Comparison of the Results of United States Bureau of Mines Microscopic Analyses with Oxidation Analyses Using 8N Nitric Acid, Dry Basis and Dry, Fusain-Free Basis

	United States Bureau of Mines				Nitric Acid Oxidation Method					
Bed	Anthraxylon, Pct	Translucent Attritus, Pct	Opaque Attritus, Pct	Fusain, Pct	Bright, Pct C_{c-1}	Dull, Pct, C_{c-2}	Fusain, Pct, C_f	Specific Reaction Constants, Pct Per Hr K_{c-1}	K_{c-2}	K_f
Pratt	51	36	8	5	77.2	16	6.8	12.62	1.28	0.82
Mary Lee	61	27	5	7	68.0	26	6.6	9.67	2.55	0.65
Fairview	57	20	8	15	58.8	29	12.2	8.25	1.66	0.95
				On Dry, Fusain-Free Basis						
Pratt	54	38	8		83	17				
Mary Lee	66	29	5		72	28				
Fairview	67	24	9		67	33				

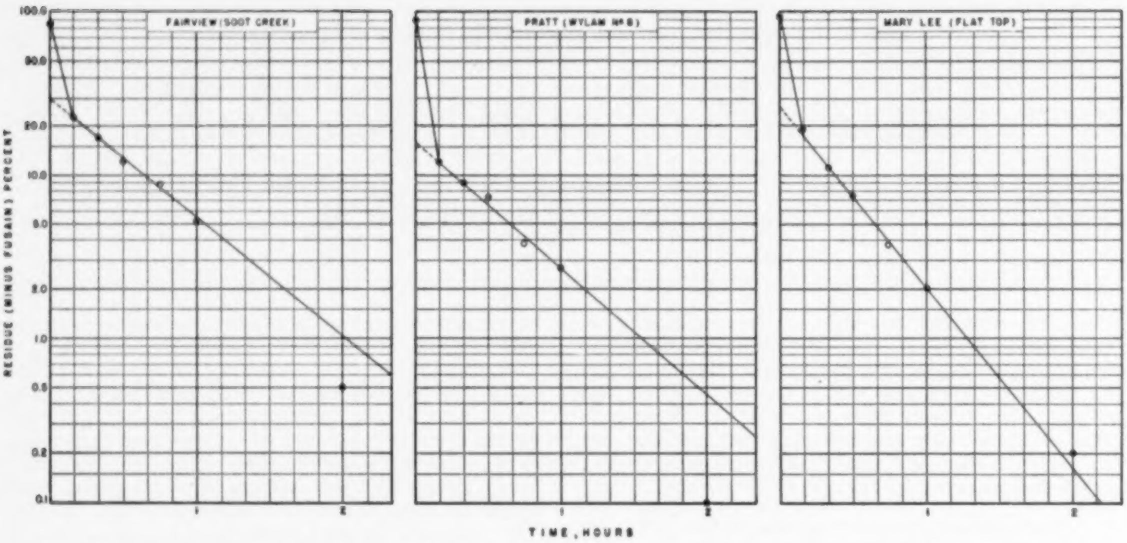

Fig. 1—Logarithm of percent total residue, less fusain residue, as a function of time of oxidation for three Alabama coals.

tained could be expected to be slightly smaller than for the entire column originally studied by the Bureau. It will be noted that the chemical method gave the expected smaller values for Mary Lee and Fairview coals but a larger one for Pratt coal.

When the experimenter attempts to determine the extent to which the components delineated by differences in oxidation rates correspond to those identified and estimated by microscopic study, he is handicapped by a lack of knowledge of the chemical differences, if they exist, between the microscopic components. From the general descriptions given of petrographic components and their properties,[3, 4] it appears certain that when specific gravity separations of coal are made, the fractions of lower density will contain some concentration of anthraxylon and of bright attrital coal, while the heavier fractions will contain most of the dull coal, or opaque material, and the fusain. Previous work[9, 10] on Alabama coals has shown that the lighter density, or bright, fractions are much more readily oxidized than the heavier, or dull, ones. For this reason the more reactive component, C_{c-1}, revealed by the oxidation analyses must include the greater part of the bright components, and the less reactive fraction, C_{c-2}, the dull or opaque components. As shown above, the fusain components determined by the two techniques appear to correspond fairly well.

Table III. Comparison of the Results of Oxidizing Lewisburg Mine, Mary Lee Bed, Coal* with 8N and 4N Nitric Acid

Conc.	C_f	C_{c-1}	C_{c-2}	C_{c-3}	K_f	K_{c-1}	K_{c-2}	K_{c-3}	Unit FC
8N	4.8	60.2	35.0		0.17	9.09	1.75		69.4
4N	4.1	47.9	32.0	16.0	0.07	5.58	0.65	0.21	69.4

* Float 1.60 — sink 1.34 fraction of washed coal.

If, as the nitric acid oxidations indicate, one component oxidizes with relative ease and another with relative difficulty, the first component must include at least the anthraxylon of the optical components and the second one at least the opaque matter of the attrital optical components. If this much is admitted, the translucent attritus, or translucent humic matter, of the optical analyses must contain some material relatively easy to oxidize and some relatively difficult to oxidize. It is not impossible, of course, that some of this material actually is of intermediate oxidizability. If such material exists, it must have been included, for the three coals of this study, in the portion which oxidized during the first 10 min of boiling C_{c-1}. Some evidence has been published of the existence of a third component in some low rank coals and even of a component intermediate between fusain and dull coal in the densest fraction of a medium volatile coal.[9] The results shown in Table III and Fig. 3 indicate three components when weaker 4N nitric acid was used for oxidations. The log percent non-fusain coal vs time plots of Lewisburg mine coal, Mary Lee bed, as oxidized with 8N nitric acid, shows no evidence of a third component. Whether or not the intermediate component was equivalent to translucent humic matter could not, of course, be determined. The great rapidity of oxidation with 8N nitric acid may mask the presence of matter of intermediate reactivity.

If as seems likely, however, there are normally only two principal components present in addition to fusain, and these components correspond roughly

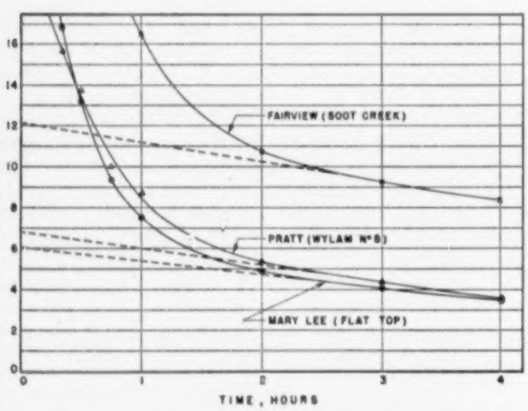

Fig. 2—Plot showing the percent total residue, after prolonged oxidation, as a function of time.

to bright coal and dull coal, it would be expected that the sum of the anthraxylon and the translucent attritus of the Bureau of Mines analyses would be larger than the bright or easily oxidized chemical component and the sum of the translucent attritus, and the opaque attritus of the Bureau of Mines would always exceed that of the more difficultly oxidized chemical component. As noted above, this was the result found in the case of all three of the coals studied. The existence of three such cases is necessary, if not sufficient, evidence for establishing a relationship between the chemical components and those differentiated and estimated optically by the Bureau of Mines.

Specific Reaction Constants

The specific reaction constants for the corresponding bright K_{c-1} and dull K_{c-2} components were very nearly the same for the three coals, as expected from the similarity of rank. The contrast between reactivity of bright and dull components for a given coal was greatest for Pratt coal and least for Mary Lee coal. For any use as a chemical raw material, such as for hydrogenation, removal of the dull component would improve Pratt coal more than it would the other two. The dull component of Fairview coal is only slightly more reactive than that of Pratt coal but it makes up twice as much of the sample.

It might prove desirable to rate coals according to their overall chemical reactivity. The case just cited, of Fairview and Pratt coal, illustrates how difficult it may be to decide which coal really has the greater overall chemical reactivity. One way to do this would be to multiply the percentage of the bright component by its specific reaction constant, the dull component by its specific reaction constant, and find the sum. Fusain could be included, but its influence on the magnitude of the sum would be insignificant. Such a weighted, overall reactivity factor or index would have units with no physical meaning. Absolute values would be meaningless also, but an index of this kind should be of value for comparing the relative overall reactivities of similar coals, oxidized under the same conditions.

Table IV shows such indexes calculated for the three coals. The dull component of each coal contributes a relatively small fraction to an index calculated in this way, in the case of Pratt coal less than three percent. Microscopic analyses yield no comparable quantitative measure of reactivity or of a correlate property.

Table IV. Overall Reactivity Indexes of the Three Coals Studied

Bed	$C_{c-1} \times K_{c-1}$	$C_{c-2} \times K_{c-2}$	Overall Reactivity Index
Pratt	1047	31	1078
Mary Lee	711	71	783
Fairview	553	55	608

It will be noticed from Tables I and IV that the overall reactivity indexes are in the inverse order of the ranks of the coals. The differences in rank are so small, however, that little significance can be attached to this result. Fusain content may have influenced the rank of the coals but not the overall reactivity indexes. Comparison analyses of coals differing decidedly in rank are needed before any final

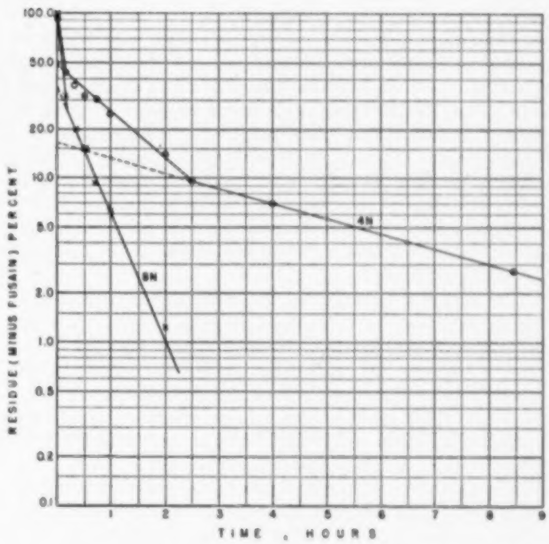

Fig. 3—Logarithm of percent total residue less fusain residue, as a function of time of oxidation by both 4N and 8N nitric acid for Mary Lee Bed, Lewisburg mine.

conclusions regarding rank-reactivity relations can be drawn.

The specific reaction constants for fusain differ slightly and increase a little with increasing quantities of fusain material present. This result suggests that fusains differ somewhat in reactivity and that apparently the coals higher in fusain contain the larger quantities of the more reactive type. At least two physically different types of fusain have, in fact, been identified in microscopic studies.[5]

Bearing on Problems of Origin and Constitution

There is little doubt that the differences in oxidation rate constants encountered with the various components of the same coals, and in coals of different rank,[9] throw some light upon the geological problems of coal origin and the nature of the factors determining rank, as well as the chemical problem of coal constitution.

Regarding the latter problem, two distinct views seem to prevail. The older one, apparently held by most workers in Great Britain as well as by many in this country, has been expressed by Lowry: "The coal molecule has resulted from condensation and polymerization of polynuclear six-membered carbon ring compounds containing hydrogen, oxygen, nitrogen, sulphur, and other elements found in coal. It is suggested, on the basis of the nature of the products obtained from the mild oxidation of coal, that an important unit of structure has essentially the same nuclear structure as humic acids."[10] Another view of the molecular structure of humic acid and, it may be inferred, the humic portions of coal, has been stated by Kinney, Polansky, and Guager: "The behavior of humic acids . . . has given credence to the fact that humic acids derived from nitric acid-treated bituminous coal are not totally characterized by a polycondensed ring structure but rather one in which the nucleus is more or less in a carbonized state approaching the character of 'amorphous' or graphitic carbon."[18]

Difference in rate of reaction with nitric acid may be explained by either picture of the dominant mole-

cule. If many of the molecules in coal material are condensed polynuclear substances, rate of nitric acid oxidation should be determined by the amount of condensation. Presumably higher rank coals or petrographic components are more highly condensed than those of lower rank and should therefore exhibit smaller reaction rate constants. Reactivity with nitric acid follows this order. On the other hand, if many molecules in coal are partly graphitized, the oxidation rate should decrease with degree of increased graphitization. This too seems to correspond with the facts.

It is difficult to account for differences in *dullness* and *brightness*, or for markedly different rates of reactivity with nitric acid and other chemical reagents shown by intimately mixed petrographic components which have been subjected, in any particular locality, to the very same dynamical agencies. The explanation may be 1—that the components came from unlike plant material or 2—that they were subjected to different chemical, biochemical, or physical forces previous to burial. One or the other of these factors has usually been resorted to for explanation of differences in chemical composition, physical appearance, or physical properties. Undoubtedly differences in reactivity toward nitric acid shown by physical components can also be traced to one or the other of these factors.

Summary

The results of this study may be summarized as follows. 1—The non-fusain portion of the coals studied consists of two components of differing reactivity toward nitric acid. 2—The *dull* component of each of the coals includes the greater part of the material in the component called *opaque attritus* and part of the material known as *translucent attritus*, to use terms employed by the Bureau of Mines; the *bright* fraction contains the anthraxylon and the remainder of the translucent attritus. 3—In one case oxidation with nitric acid of lower concentration revealed the presence of an intermediate component. This component may have represented material truly of intermediate oxidizability. It is possible that a concentrated oxidizing acid acts upon the condensed or graphitized coal structure so strongly that molecules of intermediate order of condensation or graphitization do not show rates significantly different from those of lower order. 4—The percentages of fusain, as determined by the nitric acid oxidation method and microscopic studies made by the Bureau of Mines, were in fair agreement. 5—Specific reaction constants for corresponding coal components were similar, a result expected because of the similarity in rank of the coals. 6—An arbitrary, overall reactivity index calculated from the values determined from the oxidation analyses apparently correlated with rank, but rank differences were too small for this result to be of significance. 7—The two-component nature of the non-fusain portion of the three coals, as revealed by oxidation procedures, is not inconsistent with widely accepted ideas of coal constitution and origin and rank changes in coal.

Acknowledgments

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Many of the proximate analyses and heating values and a few oxidations were made by Lamar Campbell and J. D. Cowen, student analysts. H. G. Smith, graduate student at the University of Alabama, made the 4N nitric acid oxidations of Lewisburg coal. The author wishes to acknowledge the able and timely assistance of these men.

Grateful acknowledgment is made also of the splendid cooperation of Dr. A. C. Fieldner, Dr. Bryan Parks, Dr. Ralph L. Brown, and other United States Bureau of Mines officials who furnished the samples of coal.

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aime NEWS

Phelps Dodge Gives $11,800 to Douglas Fund

Through the good offices of Louis S. Cates, Chairman of the Phelps Dodge Corp., the directors of that company have voted to give the AIME $11,800 to bring the principal of the James Douglas Medal Fund up to approximately $15,000. This amount is required to make possible an annual award of the gold medal. The James Douglas Medal was established in 1922, the first of the Institute's major medals, with the intention to bestow the award annually. Income in recent years has been insufficient, however; the last award was to Francis C. Frary in 1950.

The James Douglas Medal for distinguished achievement in nonferrous metallurgy was named in honor of Dr. Douglas, who twice served as President of the AIME, in 1899 and 1900; was Vice-President from 1906 to 1911; and elected an Honorary Member in 1906. Dr. Douglas was the first president of Phelps Dodge after its incorporation and long a dominant figure in the company. Though not educated as such he was a most ingenious, even an inspired, metallurgist. His benefactions were many, including $100,000 to the AIME to set up the James Douglas Library Fund. The present gift from the Phelps Dodge Corp. to the Institute to help keep his memory green is therefore most appropriate.

Ramsay Award

In addition to the Medals and Awards already authorized by the Board for presentation at the Annual Meeting in 1954, sufficient funds are now available to grant the Douglas and Ramsay medals as well. The former is given for distinguished achievement in nonferrous metallurgy, including both beneficiation of ores and alloying and utilization of nonferrous metals. The Erskine Ramsay medal recognizes distinguished achievement in coal mining. Suggestions for candidates to receive the awards may be addressed respectively to John D. Sullivan, Chairman, Douglas Medal Committee, Battelle Memorial Institute, 505 King Ave., Columbus, Ohio, and H. P. Greenwald, Chairman, Ramsay Medal Committee, 4800 Forbes St., Pittsburgh 13, Pa.

Annual Meeting Figures

Final figures for attendance at the Annual Meeting in Los Angeles, Feb. 16 to 19, 1953, were as follows:

Members	1576
Student Associates	78
Nonmembers	301
Students, not SA's	48
Unregistered men	116
Ladies, members WAAIME	336
Ladies, not members WAAIME	155
TOTAL	2610

Wyoming Geological Conference at Laramie

The Wyoming Geological Association will hold its Eighth Annual Field Conference at Laramie, Wyoming July 30 to Aug. 1, with facilities of the University of Wyoming available for conference purposes.

Daily field trips are scheduled for the Laramie Basin of Wyoming and the North Park Basin of Colorado. Registration will be on the campus July 29. Geomorphology of the Medicine Bow Mountain Range, structural relation of the Medicine Bow Mountains to the Laramie Basin and the sedimentary structures of the Fountain and Casper Formations of the southern Laramie Basin will be studied in the field while the last day's trip will cover the North Park Basin.

Program Ready for Nova Scotia Joint Meeting

Technical sessions, dancing, side trips, plant visits, sports, good food and the many other attractions offered by Nova Scotia, have been included in the program for the joint meeting of the Industrial Minerals Div., and the Canadian Institute of Mining and Metallurgy, with the Mining Society of Nova Scotia from September 8 to 13.

First day's activities include registration, tour of the old French fortress at Louisbourg, and inspection of blast furnace slag processing at Dominion Iron & Steel, Ltd., plant. The plant of L. E. Shaw, Ltd., at Sydney will also be visited. The inaugural reception and luncheon will be held at the Isle Royale Hotel.

The drive from Isle Royale Hotel to Keltic Lodge, headquarters of the meeting, will take registrants over the gorgeous Nova Scotia countryside, through its winding hills and past its spectacular shoreline. Following the dinner and reception, there will be a general get-together in the lodge's recreation hall.

Following the technical session Wednesday morning registrants will have a choice between visiting National Gypsum Co.'s quarry at Dingwall or taking a drive on the Cabot Trail. There are two technical sessions scheduled for the next day, and one more on Friday. Dancing will highlight Friday evening activities.

Whether you fish, swim, play golf, tennis, ping pong, shuffleboard, or would rather relax over a friendly bridge game, the Keltic Lodge offers fine facilities. Arrangements are being made for trout and deep sea fishing. A committee of Nova Scotia ladies are engaged in planning a program appealing to feminine hearts. The General Committee is holding off broaching everything it has planned and is saving several surprises.

The meeting moves to Antigonish on the afternoon of the 12th and to Halifax on the evening of the 13th.

Canadian National Railways and Trans Canada Airlines operate to and from Sydney and Halifax, with direct connection at New York, Boston, and Chicago. *Going* tickets by plane or train should be purchased to *Sydney* and return to *Halifax*. Motoring information can be obtained without charge from Imperial Oil Limited Touring Service, Corner King and Toronto Sts., Toronto, Ontario.

(Continued on page 528)

This giant tuna is an example of Nova Scotia's fabulous game fishing.

NOVA SCOTIA

MONDAY, SEPT. 7

6:00 - 10:00 pm — Early arrivals will be met by Reception Committee at the Isle Royale Hotel, Sydney, N. S. and will then register and select side trips.

TUESDAY, SEPT. 8

8:30 am - Noon — Registration continues at the Isle Royale Hotel for morning arrivals.
8:30 am — Morning arrivals breakfast at Isle Royale Hotel.
9:30 am — Tour to the old French Fortress at Louisbourg.
10:00 am — Inspect processing of Blast Furnace Slag at Steel Plant of Dominion Iron and Steel Limited, and at Plant of L. E. Shaw Limited, both at Sydney.
12:00 Noon — Inaugural Reception.
12:30 pm — Luncheon, Isle Royale Hotel.
2:30 pm — Leave Isle Royale Hotel to drive to Keltic Lodge.
5:00 - 5:30 pm — Arrive Keltic Lodge.
5:00 - 9:00 pm — Registration for those who may have proceeded direct to Keltic Lodge.
7:00 pm — Reception.
7:30 pm — Dinner.
9:30 pm — Get-together in Recreation Hall.

Additional side trips, as below, can be made available on this date:

(a) Dominion Coal Co., Ltd., will be glad to arrange for interested men only to visit a colliery and inspect the "Dosco" Miner, in operation, OR

(b) Dominion Iron and Steel Limited will be pleased to conduct interested ladies and gentlemen on a tour of their Steel Plant and/or By-Product Coke Ovens.

WEDNESDAY, SEPT. 9

10:00 am — Technical Session
1:00 pm — Luncheon
2:30 pm — Leave Keltic Lodge for
(a) Inspection of National Gypsum Co.'s Quarry at Dingwall, OR
(b) Sight-seeing drive on the Cabot Trail
6:30 pm — Reception

Unmatched scenery makes Nova Scotia a photographer's paradise.

MEETING PROGRAM

7:00 pm — Dinner
9:00 pm — Assembly in Recreation Hall

THURSDAY, SEPT. 10

10:00 am — Technical Session
1:00 pm — Luncheon
2:30 pm — Technical Session
6:30 pm — Reception
7:00 pm — Dinner
9:00 pm — Assembly in Recreation Hall

FRIDAY, SEPT. 11

10:00 am — Technical Session
1:00 pm — Luncheon
2:30 pm — Sports Contests
6:30 pm — Reception
7:00 pm — Dinner and Fun Parade
9:30 pm — Dancing

SATURDAY, SEPT. 12

Motor to Antigonish and continue later to Halifax.
3:15 pm — Special Convocation at St. Francis Xavier University, Antigonish, for the conferring of Honorary Degrees.
5:15 pm — Reception
5:45 pm — Complimentary Dinner under the joint auspices of the Government of Nova Scotia and the Governors of St. Francis Xavier University.
7:45 pm — Leave Antigonish for Halifax.

SUNDAY, SEPT. 13

The party splits for alternative tours of inspection to reunite for dinner.

PARTY NO. 1
9:00 am — Leave Hotel for tour of inspection of Canadian Industrial Minerals Limited Barites Quarry at Walton, N. S.
5:30 pm — Rejoin other parties for dinner at shore.

PARTY NO. 2
3:00 pm — Leave Hotel for tour of historic city of Halifax and nearby points of interest.
5:00 pm — Arrive at shore of St. Margaret's Bay.
6:00 pm — Lobster Boil at shore.

Alaska Student Chapter

Members of the AIME Student Chapter of the University of Alaska in front of the new Brooks Memorial Mines Building in which instruction is offered in Mining, Metallurgical, and Geological Engineering. The building was dedicated last summer in honor of Alfred H. Brooks, head of the Alaskan Branch of the U. S. Geological Survey, in the early 1900's. Back row; Leonard Gilliland, Lee Nance, Arthur Tunley, Robert Berryhill (Treasurer), William Powell, Arne Sundt, James Moore, George Mealy, Fred Rich, Ethan ones, Richard Nyman, Arthur Thompson. Second row; Nicholas Ihly, Noble Dick, Robert Lear (Vice-president), William Attwood, Mr. Jack Hoskins (Instructor). First row; Charles Proctor, Jack Garrison, George Bloom, Ervon Fairbanks (Secretary), Douglas Huber (President), James Kahle.

Around the Sections

• Some 165 members and guests of the **Southwest Alaska Section** attended the group's annual banquet held at the Aleutian Gardens in Anchorage. Pat Ryan, president of the local AIME chapter, served as master of ceremonies. Leo H. Saalela, regional mining supervisor for Alaska, and secretary of the Section, discussed the aims of the AIME. Charles E. Bunnell, president emeritus of the University of Alaska offered greetings from the **Fairbanks AIME** group. William Strandberg and Judge Anthony J. Dimond discussed prospecting in the Shushana District.

• The **Alaska Section,** battling 30 below temperatures, held a regular meeting on the University of Alaska campus recently. Scheduled for a week earlier, the meeting had been canceled because of cold weather—50 below. Chairman Earl Beistline presided. Robert Chapman was chosen Section Delegate while Harold Strandberg of Anchorage was named alternate. Several reels of color films taken at Callahan Zinc & Lead Co. placer mine were shown by Merl Thomas, thawing superintendent of the firm. At another meeting, held at the Brooks Memorial Mines Building on the campus. Douglas Huber, University of Alaska student, briefed members on the Los Angeles meeting.

• Carl F. Austin was elected President of the student chapter at the **University of Utah** for 1953. Jacques A. De Cuyper was named vice president, while Charles B. Pope was elected secretary-treasurer. Major spring activities for the group will be participation in Engineers Week with an exhibit in the school mine, and an exchange dinner meeting with the Utah Section.

• The **Carlsbad Potash Section** held two recent meetings at the Riverside Country Club. H. P. Clark, Section First Vice President presided over a meeting which heard Morris Stubbs on *The Future of the Chemical Industry in New Mexico.* Section Chairman W. P. Wilson presided at the second meeting. A technicolor sound film on the operation of International Minerals & Chemical Corp.'s potash div. was shown. Television engineer E. L. Gomeots of El Paso, Texas, conducted an open video forum.

• Feature of the **Morenci Sub-Section** meeting was the film *No Man is an Island,* depicting the lead-zinc mining, milling, and smelting operation of the Consolidated Mining & Smelting Co., of Canada. The movie followed dinner and a report by W. I. Fenzi and L. L. McDaniel on the Los Angeles meeting.

Board Changes AIME Billing Procedures

The Council of Section Delegates has recommended that consideration be given by the Board to billing new members on a pro-rata basis for the number of months remaining in the calendar year of election. The Board later approved this recommendation and the text of the necessary change in the bylaws to accomplish this was published in the Institute journals of April 1952. The plan was not immediately adopted because further study was required at Institute headquarters. This having been completed, and the practicality of the plan assured, the bylaw revision was voted by the Executive Committee. The pertinent text of Art. II, Sec. 2, 3rd sentence (see p. xxxviii of the current Directory) is revised to read as follows: "Newly elected Members, Associate Members, or Junior Members shall, on receipt of Treasurer's statement, pay the current year's dues on a pro-rata basis for the months remaining in the calendar year, including the month of elections."

Henceforth, therefore, one month will be as good as another to join the AIME. If elected in June, for example, he would be billed for seven twelfths of the annual dues, and would receive the journal of his choice for the rest of the year.

Coal Show Schedules Great Many Exhibits

An impressive list of exhibitors will be on hand for the American Mining Congres Coal Show, May 11 to 14 at Cleveland's huge Public Auditorium. Highlighted at the show this year will be advances in coal production and preparation.

Special attention is planned for certain critical safety and management problems. Sessions will be held each morning and Tuesday and Wednesday afternoons. They will include roof bolting, pillar recovery, mechanical mining, degasification, and many other aspects of production.

Personals

WILLIAM BELLANO

W. C. SCHROEDER

K. P. WANG

William Bellano was appointed chief project engineer in charge of mining for International Minerals & Chemical Corp.'s engineering div. A graduate of Pennsylvania State College, Mr. Bellano comes to International with over sixteen years of mining experience, both in the United States and abroad. His background includes experience in mining copper, zinc-lead, tin coal and other minerals. **James L. Taylor** has been made chief project engineer in charge of construction for International Minerals & Chemical Corp.'s engineering div. and **Robert F. Marek** has been made chief project engineer in charge of industrial engineering for the corporation's engineering div.

Merlynn O. Anderson was selected by the faculty of the University of Utah as the outstanding senior in mining engineering and was awarded a gold watch by the Old Timers Club. The presentation was made by **Dr. L. E. Young,** a former president of AIME. Mr. Anderson worked in coal mines in Utah; served in the United States Army; and began his mining education at Carbon College, completing his course at the University of Utah under a cooperative plan existing between the college and the university.

James A. Barr is resigning as Chief Industrial Minerals Branch Defense Materials Procurement Administrator in April. He is returning to his home in Mt. Pleasant, Tenn., where he will resume his private consulting practice.

Guy N. Bjorge, general manager, Homestake Mining Co., Lead, S. D., retires as of May 12, 1953, after 21 years of service there. He will continue as a consultant and director. However, he will be located at the Homestake offices in San Francisco. **A. H. Shoemaker** will succeed Dr. Bjorge. Mr. Shoemaker comes to the Homestake Mines Co. from the Triumph Mining Co. in Idaho where he has been manager.

W. C. Schroeder, assistant director of the Bureau of Mines for programming has been away from Washington, D. C. on official business in Burma where he has been making a thorough on-the-spot review of the requests of the Burmese government for technical assistance under TCA in the field of mineral resources.

George W. Bruce has been appointed works manager of the Claymont Plant of the Colorado Fuel & Iron Corp. at Claymont, Del. Mr. Bruce has been associated with the steel industry for the past 22 years. Prior to joining CF&I, he held positions with Midvale Steel Co. and United States Steel Corp. and with the Steel Co. of Canada as assistant works manager at Hamilton, Ont.

R. B. Caples, manager of the Great Falls Reduction Works of Anaconda at Great Falls, Mont., has been elected president of the Anaconda Aluminum Corp. and will be located in New York City.

F. O. Case resigned as president of the Anaconda Aluminum Corp. to accept the presidency of the Glen Alden Coal Co., Wilkes Barre, Pa.

John F. Ewing has recently completed work on a Ph.D. in metallurgical engineering at the University of Michigan and has accepted a position with the Babcock & Wilcox Co.

Andrew Fletcher was made an honorary member of the Australasian Institute of Mining and Metallurgy, Melbourne, Australia at their annual meeting in April.

Sven B. Gafvert is now employed by the Joy Mfg. Co. in Claremont, N. H.

Edmond V. Given is with the Societe des Mines de Zellidja in French Morocco where he expects to be for the next two years.

T. K. Graham, superintendent of the zinc plant of the Great Falls Reduction Works of the Anaconda corp., has been promoted to general superintendent of the Great Falls plant.

K. P. Wang, chief, Far East Branch, Asian Div., Region IX, Bureau of Mines, left Washington, D. C. in February for Rangoon, Burma, on official business which has taken him to the outlying mining areas of the country. He is now en route to Tokyo, Japan where he will participate at the ECAFE conference of United Nations before going on to the Philippine Islands to consult with the MSA staff relative to minerals resources project work in which the Bureau of Mines has an important part.

Robert E. Hayes has left the Bunker Hill & Sullivan Mining & Concentrating Co. at Kellogg, Idaho, and is now employed by the Polaris Mining Co. at their Silver Summit Mine in Wallace, Idaho.

Ira K. Hearn, Jr., formerly assistant to **Charles R. Cox,** Kennecott's president, has been appointed industrial engineer for the company's western mining divisions.

Otto Herres, vice president of Combined Metals, has been elected vice chairman of the Mining Standards Board of the American Standards Association, representing the metals groups.

Harry M. Hoppe, Jr. has been accepted on the engineering staff of the new Cornelia Branch of the Phelps Dodge Corp.

Jack Q. Jones has secured a position as a mineral dressing engineer with the American Cyanamid Co.

C. P. Keegel will be engaged for several months in mining advisory and appraisal work in the Oriente Province of Cuba. He can be reached at Apo. 612, Santiago de Cuba, Cuba.

A. G. Mosier has been working as an analytical chemist in Uravan for the United States Vanadium Co., a division of Union Carbide and Carbon Corp.

Personals, Cont'd

Henry Mulryan, past director of the Los Angeles Chamber of Commerce and ex-chairman of the civic organization's mining committee, was honored by fellow committee members for six years of service to the mining industry and the community. A plaque expressing appreciation was presented by Peter Colefax, mining committee chairman. The award was made at a recent meeting of the mining committee in the board of director's room at the Chamber. Mr. Mulryan is president of the Sierra Talc & Clay Co.

Eiichi Nomura has been assigned his new duties as vice-general manager of the Hitachi Mine, Smelter and Refinery of Hitachi Kogyosho Co.

L. F. Paddison, mining and geological engineer with the United States Smelting, Refining, & Mining Co. at Boston, Mass., retired under the company's retirement plan on March 31st. He entered the company's employment in 1914 and has been with the company continuously except for the years 1922 and 1923 when he was chief engineer for the Magma Copper Co. Mr. Paddison will continue to reside in Auburndale, Mass., and plans to engage in a limited amount of consulting work.

Norbert N. Peters is now employed by the National Lead Co. of Ohio.

John T. Ryan, Jr., executive vice president of Mine Safety Appliances Co., has been presented the Duquesne Management Award for leadership in management by the Duquesne University chapter of the Society for the Advancement of Management.

Raymond F. Robinson has resigned from his position as chief geologist for the Sunshine Mining Co. at Kellogg, Idaho in order to join the U. S. Geological Survey.

Odin A. Sundness was elected a vice president in charge of mining operations of Snyder Mining Co.'s properties in Minnesota. Mr. Sundness has been associated with the Shenango Furnace Co. and Snyder Mining Co. since 1911. During these years he has filled the positions of chief chemist, chief mining engineer and general superintendent on the Mesabi range. He has been general manager of operations since August 1946.

Berl A. Trafton was released from active duty with the Aviation Engineers on Dec. 17, 1952 and is now employed as a junior mining engineer with the Pend Oreille Mining & Metals Co., Metaline Falls, Wash.

John S. Marsh formerly resident engineer with Bethlehem Steel Co. has been made assistant chief of research.

George B. McMeans, works manager at Fontana, Calif., has been promoted to vice-president in charge of operations for Kaiser Steel Corp.

Walter F. Meckel is leaving the employ of the Hochschild interests in Bolivia after 19 years in Potosi.

A. H. Ross has joined the Climax Uranium Co. as assistant to the vice-president and general manager.

George C. Selfridge, chief, iron and ferroalloy div., Defense Minerals Exploration Administration has been assigned to the position of special assistant to the administrator.

Robert Langland Smith is now employed by the Warner Co. in Bellefonte, Penna.

F. S. Weimer, general superintendent of the Great Falls Reduction Works of the Anaconda Corp., has been promoted to manager of same.

John L. G. Weysser, consulting mining engineer, recently moved to Pottsville, Pa., where his address is 712 Mahantongo St.

Colonel C. F. Williams is on an extended cruise in the Pacific and will not be in this country until the latter part of July.

Richard H. Willey has resigned as general hill foreman at Kennecott's Bingham mine to take a job as general superintendent of an open-pit iron mine operated by Philippine Iron Mines, Inc., Luzon, Philippine Islands. **Albert Kastelic** has been named by Kennecott's Utah Copper Division to succeed Mr. Willey as general hill foreman.

R. D. Urquhart is now associated with the Western Machinery Co. as a sales engineer.

Emerson Clark Lane, of Port Orchard, Wash., has been promoted to chief engineer for Frontino Gold Mines, Ltd., Otu, Colombia.

Harold E. Lake, general superintendent, has become manager of the Port Radium development on Great Bear Lake, Northwest territory, for Eldorado Mining & Refining Co., Ltd. **Richard E. Barrett,** former professor of mining at the University of Toronto, is manager at Beaverlodge, Alta.

FELIX E. WORMSER

Felix E. Wormser, New York business executive, has been appointed Assistant Secretary of Interior for mineral resources. Mr. Wormser is co-author of the book "Marketing of Metals and Minerals" and has contributed articles to the technical press. His earlier career was spent as a mining engineer for Cornucopia Mines Co. in Oregon and for the U. S. Bureau of Mines in Washington, D. C. He was at one time on the editorial staff of McGraw-Hill Co., New York City. Mr. Wormser was secretary-treasurer and president of Lead Industries Assn. and a member of primary lead producers industry advisory committee, W.P.B. Besides being an AIME member, he holds membership in the Mining and Metallurgy Society of America of which he was past president, Society of American Military Engineers, and the Society of Automotive Engineers. Among some of his activities, Mr. Wormser is general chairman of the Columbia University Engineering Center Development.

J. Maureese Powelson, formerly with Johnston and Powelson, geologists of Toronto, Ont., has joined the geological and exploration department of the American Metal Co., Ltd., New York.

R. G. Aguilar is now employed by the Chicago Pneumatic Tool de Mexico, S. A., representing the company in Northwestern Mexico with headquarters in Chihuahua, Mexico.

C. M. F. Peters accepted a position with Pierce Management last October. Pierce Management has been given the job of examining and appraising the mineral resources of Burma and to make recommendations as to how to develop them. Mr. Peters has been assigned as resident engineer to cover the Kachin State.

Leonard C. Clark is chief engineer and geologist with Sang Dong and Dal Sung Mines of Korean Tungsten Mining Co., under management agreement with Utah Construction Co.

E. L. Ralston has been named manager of Glidden Paint Co. mining properties, directing operations at the zinc and copper mines in Shasta County, Calif., and barytes mines at Battle Mountain and Tonopah, Nev.

Myron Read has been appointed plant manager of the Fort Dodge, Iowa, gypsum plant of Certainteed Products. Mr. Read joined the company in 1945 as a mining engineer.

Scott Turner, past president of the AIME, has been elected president of the American Institute of Consulting Engineers, New York.

V. A. Brussolo, former vice president of Soriano & Co. in Manila, P. I., who is now connected as consultant with DMPA, in the Minor and Light Metals Section, Washington, D. C., recently returned from an inspection trip to the Seward Peninsula, Alaska in connection with the Lost River mine of the U. S. Tin Corp.

Carl Gommel has been appointed to the engineering staff of the Colorado School of Mines Research Foundation, Golden, Colo. Dr. Gommel was formerly mill superintendent with Aramayo de Minas in Bolivia.

Arthur E. Hepburn is president and general manager of the Nevada Perlite Corp., Inc. in Nevada. This company is arranging to build a plant to crush and size perlite, ready for popping.

E. Thomas Hight is mine foreman with the International Minerals & Chemical Corp. at Bartow, Fla.

C. E. McManus, formerly assistant general manager of Hollinger-Hanna Ltd., operating for the Iron Ore Company of Canada in the Quebec-Labrador iron ore project, has been appointed project manager in charge of all operations. Messrs. **J. A. Little** and **A. J. LeBlanc** are assistant managers.

C. P. Keegel is now located at Santiago de Cuba, Cuba, where he is presently engaged in mining appraisal work.

E. C. Roper, general manager of Britannia Mining & Smelting Co., Ltd., Britannia Beach, B. C., was elected president of the Mining Association of British Columbia, succeeding **M. M. O'Brien,** managing director of Bralorne Mines, Ltd., Vancouver.

R. P. Gerwels, consulting engineer associated with P. J. Shenon, has gone to Minas de Matahambre as chief engineer.

Obituaries

T. W. Anderson (Member 1951) died. Born in Chicago, Ill., he worked for the U. S. Steel Co. since 1899 up until 1949. He started out as an office boy and gradually worked his way up to draftsman, worked in open-hearth shop, and then became electric furnace melter and turn foreman. His last position was sales engineer with Exothermic Alloys Sales & Service, Inc.

John L. Bray (Member 1923) died on Dec. 6, 1952. Dr. Bray was a professor of metallurgy on the Purdue University staff since 1923, and head of the school of chemical and metallurgical engineering from 1935 to 1947. The Purdue educator was born in Millbridge, Mass., and was graduated from Massachusetts Institute of Technology in 1912 and obtained a doctorate there in 1930. He had eight years' experience with mining companies in Central and South America and British Columbia, and taught for a year at MIT and at Nova Scotia Technical College, and served a year with the U. S. Tariff Commission in Washington before coming to Purdue. He was the author of several text books in the field of metallurgy and was a widely recognized authority in this field. Last year he was awarded the Sigma Delta Chi, journalistic fraternity, "Best teacher" award made annually. Dr. Bray was a member in many learned societies and was active for some years in most of them.

Glenville A. Collins (Member 1907) died on November 12, 1952. Mr. Collins was at one time manager of engineering div. of Southwestern Engineering Co. in Los Angeles. He had his own private consulting practice in Los Angeles and San Francisco. He was well known for designing and in the erection of machinery.

Charles H. Herty, Jr. (Member 1938) died on January 17, 1952. Dr. Herty became widely known during and after World War II for his work on the conservation of manganese and other raw materials of steelmaking. Mr. Herty fathered in this country the science of physical chemistry of steelmaking. Thirty years ago there was little appreciation of the fact that steelmaking reactions are subject to the laws of physical chemistry and suitable data in this field were practically non-existent. His studies were carried out at MIT's School of Chemical Engineering Practice; at the U. S. Bureau of Mines, Pittsburgh station; with the Metallurgical Advisory Board in Pittsburgh; and finally with Bethlehem Steel Co.—with results soon to be known and quoted throughout the world.

Samuel S. Marshall (Member 1938) died on Dec. 8, 1952. One of his last positions was vice president in charge of manufacturing operations of J&L Steel Corp. He has been with this company since 1903 and started out as an engineer and master mechanic in Eliza, Soho and South Side Departments, he then became assistant general superintendent of Eliza Dept. of J&L. In 1928 he was made general superintendent of South Side Works and in 1929 he was made general superintendent of Pittsburg Works.

Vivian U. Strange (Member 1940) died on April 14, 1952. Mr. Strange did special work at Columbia University, School of Mines. He was U. S. Deputy Mineral Surveyor for about ten years beginning in partnership with Albert Burch at Salt Lake City, Utah. The Great Bear Mining Co. employed him in engineering practice and in management of the company.

Edward A. Uehling (Member 1886) died on December 21, 1952. Mr. Uehling was the oldest member of the AIME. One of his first positions was as assistant professor for two terms at the Stevens Institute of

Technology, investigating the properties of cold rolled steel. In the following years he was a draftsman or engineer for several furnace companies until he went to the Bethlehem Iron Co. as chief chemist. From 1890 to 1895 he was superintendent of the Sloss Iron & Steel Co. He then opened the Uehling Instrument Co. at Paterson, N. J. and headed that company until his retirement in 1919 when he returned to Wisconsin. He patented more than 20 inventions including the first practical pyrometer, an instrument to record temperatures up to 2,500°F; a pig iron casting machine that is still in use in all large ironmaking plants, and a recorder which continuously records the percentage of carbon dioxide in flue gas. Mr. Uehling besides being a member of AIME, was a member af American Society of Mechanical Engineers, the Engineers' Society of Milwaukee, Delta Tau Delta and Tau Beta Pi. In addition to his son, Edward, who is a hydraulic engineer for the Allis-Chalmers Mfg. Co. Mr. Uehling is survived by another son, Frederic, who heads the Uehling Instrument Co. at Paterson that his father founded.

J. H. Watkins (Member 1914) died on October 27, 1952. Mr. Watkins contributed articles to Transactions of AIME and wrote papers for Engineering & Mining Journal. He had experience in examining and exploiting mineral substances occurring in the Southern States and for a period of time had his own private consulting practice. The Development Service of Southern Railway employed him as an economic geologist. He attended the Virginia Polytechnic Institute.

NECROLOGY

Date Elected	Name	Date of Death
1928	Clifford P. Bowie	Apr. 1, 1952
1942	Sanford H. Casteel	June 20, 1952
1903	Firmin V. Desloge	May 18, 1952
1948	H. T. Herivel	Nov. 17, 1952
1905	Albert W. Johnston	Unknown
1944	Albert J. Jones	Dec. 1, 1952
1907	Charles Lessner	Unknown
1918	Alexandre Lheraud	December 1951
1941	Poole Maynard	Aug. 22, 1952
1948	Frank G. McClure	Mar. 2, 1953
1938	David M. Miller	Mar. 8, 1952
1884	Philip S. Morse	Mar. 1, 1953
1946	Walter J. Mullally	January 1952
1927	J. S. Peterson	Mar. 13, 1953
1935	Earl G. Schulz	Unknown
1886	Edward A. Uehling	Dec. 21, 1952

Proposed for Membership

MINING BRANCH, AIME

Total AIME membership on Feb. 28, 1953 was 18,262; in addition 2,008 Student Associates were enrolled.

ADMISSIONS COMMITTEE

O. B. J. Fraser, Chairman; Philip D. Wilson, Vice-Chairman; F. A. Ayer, A. C. Brinker, R. H. Dickson, Max Gensamer, Ivan A. Given, Fred W. Hanson, T. D. Jones, George N. Lutjen, E. A. Prentis, Sidney Rolle, John T. Sherman, Frank T. Sisco, R. L. Ziegfeld.

The Institute desires to extend its privileges to every person to whom it can be of service, but does not desire as members persons who are unqualified. Institute members are urged to review this list as soon as possible and immediately to inform the Secretary's office if names of people are found who are known to be unqualified for AIME membership.

In the following list C/S means change of status; R, reinstatement; M, Member; J, Junior Member; A, Associate Member; S, Student Associate.

Alabama
Birmingham—Fanning, Alfred N. (C/S—A-M)
Birmingham—Smith, Walton F. (J)
Fairfield—Cunningham, Gordon R. (J)
Tuscaloosa—Dorenfeld, Adrian C. (C/S—A-M)

Arizona
Hayden—Galbiati, Donald V. (J)

Arkansas
Bauxite—Fuller, Julian A. (C/S—A-M)

California
Eureka—Harris, Jack (R. C/S—J-M)
San Carlos—Corrigan, Graham H. (A)
San Francisco—Merrill, John L. (M)

Colorado
Denver—Goss, Eugene R. (M)
Denver—Matthews, Murrell (O) (A)
Denver—Morgan, Edward A. (R. C/S—J-M)
Pueblo—Purdy, John R. (M)

District of Columbia
Washington—Mentch, Robert L. (J)
Washington—Simons, Frank S. (M)

Florida
Bartow—Booream, John W. (A)
Lakeland—Bergquist, Richard B. (J)

Idaho
Kellogg—Osborne, Nathan J. (M)

Illinois
Brookfield—Bemis, Frank A. (R. C/S—J-M)
DuQuoin—Albon, Dean E. (C/S—A-M)

Indiana
Bloomington—Hoadley, John A. (A)

Kentucky
Lexington—Harelson, William H. (C/S—S-J)

Maryland
Woodstock—Feeney, Aquin P. (A)

Minnesota
Virginia—Hahne, Edward H. (J)

Missouri
Bonne Terre—Brady, Bernard F. (J)

Montana
Basin—MacGinniss, John (M)
Gold Creek—Connors, James A. (R. C/S—S-M)

Nebraska
Grand Island—Vogt, Thomas L. (C/S—S-J)

New Jersey
East Orange—Hendershot, Frederick V. (R. C/S—S-M)
Ridgewood—Hollister, Kenneth C. (A)

New Mexico
Carlsbad—Phillips, Ira B. (M)

New York
Essex—Baker, John F. (R. C/S—S-A)
Mt. Vernon—Petrick, Alfred, Jr. (C/S—S-J)
New York—Sikka, Desh B. (C/S—S-J)
Port Henry—Butterfield, Howard M. (R. C/S—A-M)

Ohio
Berea—Case, Leslie M. (R. M)
University Hts.—Liggett, Robert P. (R. C/S—J-M)

Oregon
Portland—Palmer, Leroy A. (R. M)

Pennsylvania
Pittsburgh—Summers, Milo W. (R. M)
Pottsville—McCarron, John F. (A)
State College—Bitner, Abraham W. (C/S—A-M)
State College—Channabasappa, Kenkere C. (J)
State College—Phelps, Donald D. (R. C/S—S-J)
Tamaqua—Marinier, Joseph D. A. (A)

Tennessee
Knoxville—Colman, Hugh C. (R. C/S—S-J)

Texas
Dallas—Jones, Hal J. (M)
El Paso—Kannady, Hardy F. (C/S—A-M)
Ingram—Gerry, Alex L. (M)

Utah
Bingham Canyon—Johnson, Clarence L. (M)
Salt Lake City—Ballard, Burton L. (M)
Salt Lake City—Mitchell, J. Stanley (C/S—A-M)
Salt Lake City—Whiton, Warren W. (J)

Vermont
Barre—Cary, Richard W. (M)
Pocahontas—Porterfield, Charles W. (J)

Washington
Tacoma—Maddess, Mathew S. (R. C/S—J-M)

West Virginia
Fairmont—Berry, Charles E. (M)

Wisconsin
Milwaukee—Person, Rolph A. (J)

Alaska
Anchorage—Bashaw, Calvin F. (A)
Anchorage—Matheson, Hugh J. (J)

Australia
New So. Wales—Cuthbert, Robert H. (J)

France
Paris—Astier, Jacques E. (M)

Germany
Gelsenkirchen-Buer—Hoevels, Carl W. (M)

Italy
Genoa—Chinaglia, Carlo (M)

Ontario
Falconbridge—Healy, Edward L. (C/S—A-M)
Lakefield—Allen, Jules P. (M)
Leaside—Watts, Murray E. (M)
Toronto—Hardon, Francis B. (A)

Peru
Cerro de Pasco—Diaz-Chavez, Javier (J)
Cerro de Pasco—Hood, Stanley R. R. (M)
Lima—Johnson, Robert F. (M)
Pacasmayo—Morton, Walter F. (C/S—S-J)

Quebec
Town of Mt. Royal—Ed, Kenneth M. (A)

W. Africa
Liberia—Viola, Hubertus (M)

—Coming Events—

May 11-14, American Mining Congress Coal Convention & Exposition, Public Auditorium, Cleveland.

May 14-16, Pacific-Northwest Metals and Minerals Conference of 1953, joint meeting of Metals Branch and Industrial Minerals Div., Ben Franklin Hotel, Seattle.

May 14-23, Thirtieth Anniversary International Petroleum Exposition, Tulsa.

May 16, St. Louis Section, Presidential Visit and Ladies' Night, St. Louis.

May 18-20, Annual Spring Meeting of Metal Treating Institute, Hotel Shamrock, Houston.

May 18-22, Fifth National Materials Handling Exposition, Convention Hall, Philadelphia.

June 3-7, Chemical Institute of Canada, Windsor, Ont.

June 12-13, Spring Meeting, Central Appalachian Section, AIME, Beecher Hotel, Somerset, Ky.

June 16-19, Exposition of American Welding Society, Shamrock Hotel, Houston, Texas.

June 16-19, Materials Conference held concurrently with First Exposition of Basic Materials, Hotel Roosevelt, New York.

July 13-16, Golden Jubilee of the Idaho Mining Assn., Sun Valley, Idaho.

Sept. 8-12, Joint Meeting Industrial Minerals Division, AIME, Keltic Lodge, Ingonish, Nova Scotia.

Sept. 11, St. Louis Lead Belt Meeting, Tour of St. Joseph Mines and Mills, St. Louis.

Sept. 21-23, American Mining Congress Mineral Mining Convention, Olympic Hotel, Seattle.

Oct. 8-9, Ninth National Conference on Industrial Hydraulics, Hotel Sheraton, Chicago.

Oct. 15-17—Second Annual Clay Minerals Meeting, University of Missouri, Columbia, Mo.

Oct. 19-21, Institute of Metals Division, Fall Meeting, Hotel Allerton, Cleveland.

Oct. 28-31, AIME, El Paso Meeting, in cooperation with International Mining Days, Paso Del Norte, El Paso.

Oct. 29-30, AIME, ASME Fuels Conference, Conrad Hilton Hotel, Chicago.

Oct. 29-31, Annual Meeting of National Council of State Board of Engineering Examiners, Plaza Hotel, San Antonio.

Advertisers' Index

* Previous Issues